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Progress in RANGE RESEARCH 17 Western States

FOR USE BY RANGE RESEARCH LEADERS

1959



compiled by
State Experiment Stations Division
Agricultural Research Service
UNITED STATES DEPARTMENT OF AGRICULTURE

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This compilation, progress and activity in the arid and semiarid parts of the United States. Publication of research results verified in subsequent years from this compilation. Permission of the research is available only to administrators.

The reports include information on plant variety and strain evaluation, water utilization studies are reported, they are an integral part of progress information obtained through the West

Conferences. Annual reports of pertinent regional research projects are also included. A list of recent range research publications is appended.

The length of the reports are not necessarily indicative of the amount and concentration of the research they present, because most Federal reports are digested summaries of range research progress and some State reports are more condensed than others.

Since this is the first compilation combining range research information from the State Stations and the Federal agencies engaged in range research on drylands, many of the reports contain procedural information and objectives or aims to be accomplished. The names of the project leaders are listed with their project reports, or in the case of some of the Federal reports, in a separate list. If a range scientist requires more information or answers to specific questions on a particular research or the problems being studied, he can write directly to a project leader. The reports are reproduced essentially as written by the respective project leaders or by the agency representatives who have coordinated the research progress information. Naturally, this has resulted in differences in style, format and detail of information included in this compilation.

An advisory committee has provided many valuable suggestions for the development and organization of this compilation. This committee includes -- R. R. Humphrey and R. M. Love, representing the State agricultural experiment stations; Wesley Keller, D. L. Klingman, and J. S. Robins, representing the Agricultural Research Service; and E. H. Reid and W. O. Shepherd, representing the Forest Service.

communication of research problems in the arid and semiarid parts of the United States. It may or may not be statements or results without the express permission of the research or their

economics, fertility, plant physiology, plant variety and their supplementary feeding studies are omitted unless on study. Research on plants is being disseminated through the Alfalfa Improvement

PROGRESS IN RANGE RESEARCH
17 WESTERN STATES

1959

For Use by Range Research Leaders

Information was supplied from the following State agricultural experiment stations and Federal agricultural research organizations. The men listed assembled the information from their colleagues for inclusion in this compilation.

State Agricultural Experiment Stations

Arizona	- D. G. Wilson	North Dakota	- W. W. Whitman
California	- R. M. Love	Oklahoma	- Wayne Huffine
Colorado	- D. F. Hervey	Oregon	- C. E. Poulton
Idaho	- E. W. Tisdale	South Dakota	- J. K. Lewis
Kansas	- K. L. Anderson	Texas	- W. G. McCully
Montana	- G. F. Payne	Utah	- C. W. Cook
Nebraska	- D. F. Burtzlauff	Washington	- G. A. Harris
Nevada	- J. H. Robertson	Wyoming	- A. A. Beetle
New Mexico	- K. A. Valentine		

Agricultural Research Service, U. S. Department of Agriculture

Crops Research Division:

Crops Protection Research Branch - D. L. Klingman
Forage and Range Research Branch - Wesley Keller

Soil and Water Conservation Research Division:

Western Soil and Water Management Research Branch - J. S. Robins

Forest Service, U. S. Department of Agriculture

Division of Range Management and Wildlife Habitat Research - K. W. Parker

Final assembling, printing and distribution was done by the State Experiment Stations Division, Agricultural Research Service, U. S. Department of Agriculture.

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Cover page: Two-man crew charting a meter-square quadrat with a pantograph. (Courtesy of U. S. Forest Service.)

STATE AGRICULTURAL EXPERIMENT STATIONS

ARIZONA

Title: ANNUAL RING STUDIES OF DESERT SHRUBS

Leader: C. Wesley Ferguson, Department of Watershed Management

Objectives: To provide a sound basis for the application of annual ring studies of woody southern-desert shrubs to problems in ecology, botany and archaeology.

Procedures: 1. Woody stem material of plant species in and adjoining the desert grassland of southwestern United States and northern Mexico will be collected, prepared and analyzed. Analysis will utilize dendrochronological concepts and techniques as presented by Schulman in a publication entitled "Dendroclimatic Changes in Semiarid America," University of Arizona Press, Tucson, Arizona, 1956.

2. The gross structural features of stem growth and the positive or negative value of the growth pattern of the species in regard to ring analysis will be determined.

3. As a result of the above extensive species survey, a report will be published on the species which have positive value in ring studies. This would include measurement and plotting of ring chronologies of species, age classes and geographical areas.

4. Duplicate stem herbaria of all species studied will be collected and prepared for deposition at the Laboratory of Treering Research (University of Arizona) and the Arizona-Sonora Desert Museum, Tucson, as an aid to botanists and archaeologists in identification.

Progress: The project continued a previous study of growth rings in big sagebrush (Artemisia tridentata) and an exploratory investigation of growth rings of woody plant species in and adjoining the desert grassland of southwestern United States and northern Mexico. Preliminary studies indicate that the woody stems of many shrubby species have definable annual growth rings. Interpretable ring chronologies have been found in serviceberry (Amelanchier spp.), big sagebrush (Artemisia tridentata), netleaf hackberry (Celtis reticulata), rabbitbrush (Chrysothamnus nauseosus), two species of Mormon tea (Ephedra spp.), bitterbrush (Purshia tridentata) and sumac (Rhus microphylla).

Title: RESEEDING OF ARIZONA RANGES

Leaders: Louis P. Hamilton, University of Arizona Plant Materials Center
David G. Wilson, Department of Watershed Management

Objectives: To obtain information on the factors affecting germination and establishment of forage plants capable of growing in Arizona without irrigation.

Procedures: Grasses, forbs and browse of potential forage or conservation value will be field-planted at sites that appear to offer possibilities of establishment. Various planting methods, such as pitting, chiseling, contour furrowing, brush control and mulching will be investigated. Germination and survival data will be obtained on each species at each site and for each planting method.

Basic studies on conditions requisite for germination and growth will be obtained under controlled temperature, light and humidity as these facilities become available.

Progress: A dryland test site was established in the Linden area. Various species and accessions of Agropyron and Bromus are being investigated for possible use on the problem areas in the pinyon-juniper coniferous forest zones.

A replicated rod-row planting was set out in the vicinity of Holbrook. Lines or varieites of galleta, Caucasian bluestem, Turkestan bluestem, blue grama, sideoats grama and Boer lovegrass are being tested.

Two outstanding lines of Boer Lovegrass (A-84 and A-12752) were set out in replicated plantings in Cochise County. This species appears to be superior to others tested in the desert grassland area.

Title: SEED INCREASE AND PRELIMINARY EVALUATION OF PLANT INTRODUCTIONS
THAT MAY BE SUITED TO THE SOUTHWEST

Leaders: Louis P. Hamilton, University of Arizona Plant Materials Center
David G. Wilson, W-6 Technical Committee Member

Objectives: 1. To provide for initial increase of seed of plants potentially adapted to the Southwest.

2. To conduct preliminary evaluations of the adaptability of new plants that appear suited to southwestern climatic conditions.

Procedures: 1. Germ plasm will be maintained in its original composition insofar as reasonable within the interest of the W-6 regional program.

2. Seed will be harvested and sent to the Primary Station for distribution.

3. Qualitative evaluation reports will be prepared annually, giving general appearance and performance of all accessions grown. This information will be sent to the Primary Station (Pullman) for incorporation in the regional system of reports.

4. Accessions will be regrown at intervals that will assure maintenance of viable seed.

5. A balanced program of increase and preliminary testing will be maintained between foreign and native plant introductions.

Progress: Astragalus armeniacus (P.I. 214,095), Astragalus mexicanus (P.I. 214,097) and Astragalus stipulatus (P.I. 214,101) made vigorous growth and survived the summer heat. They appear similar to Astragalus cicer which has proved promising for high elevation seedings.

Eragrostis curvula (P.I. 232,831) is a vigorous growing number surpassing A-67 in leafiness. It has a rapid recovery after clipping in the late summer.

Indigogera spp. (P.I. 214,167) from India offers a low perennial shrub for windbreaks which is notably free of insect damage or leaf diseases.

One number of Smilo grass, Oryzopsis miliacea (P.I. 234,483) retains green leaves and stems into maturity and may offer later range production than other numbers.

Phalaris tuberosa (P.I. 202,480 and P.I. 240,249) both from Morocco have proved the earliest grasses to produce forage in the spring that the Center has tested. The Center has taken over P.I. 202,480 and is determining its growth curve through the season and making clonal selections for earliness.

Title: CHANGES IN THE DESERT GRASSLAND - AN ANALYSIS OF CAUSES

Leaders: Robert R. Humphrey, Department of Watershed Management.
Joel E. Verner and Patrick D. Dalton.

Objectives: To determine the changes in plant cover and in the factors affecting plant cover that have taken place in the Southwestern grasslands since white settlement.

Procedures: Detailed studies will be conducted on the desert grassland complex and on specific plants which are prevalent in the type. See progress below for procedural details

Progress: The objectives on an ecological study of creosotebush are to determine past and present distribution, degree of invasion of the desert grassland and the factors affecting spread of this shrub into grassland areas. Seeds germinate under a wide range of temperature, light and pH. Vegetative growth and fruiting are correlated with soil moisture. Flowering as a response is more immediate than leaf and stem production. Leaf-moisture contents range from 25% during drought to 59% during the rainy season. The plants generally sprout from the base after burning. Root development is correlated with available moisture.

The ecology of tobosa grass is being studied as a second phase of this project. Three kinds of sites are being studied: (1) lowland swales, (2) hillsides in a desert-shrub type, and (3) level plateaus with little other vegetation. Soil moisture determinations on a swale-type site are made at weekly to bi-weekly intervals. Moisture analyses are being made at 1", 6", 12", and 18" depths in the tobosa stands and on adjacent non-grassed areas to correlate soil moisture with occurrence of tobosa.

Title: THE RANGE RESOURCES OF ARIZONA

Leader: R. R. Humphrey, Department of Watershed Management

Objectives: 1. To develop an analysis of range condition classes on each of the major forage types of the principal grazing counties of the state.

2. To develop an analysis of upward and downward range condition trends in the principal grazing counties of the state.

3. To assemble information on the grazing value of each of the more common plants mentioned.

4. To present range management techniques for each condition class in each of the major forage types.

Progress: Work previously begun on Pima, Pinal and Santa Cruz Counties has been completed. Vegetation maps of these counties have been prepared and cuts for color reproduction have been made. The data that have been collected and written up include: (1) range forage type descriptions, (2) range condition analyses on each type and on sites within types, (3) photographs of the various types and condition classes, (4) a statement of the forage value and a line drawing of each forage species mentioned in the text, and (5) a statement of the range management practices required for range improvement or maintenance.

Title: TRANSPIRATION BY RANGE AND WATERSHED PLANTS

Leaders: David R. Kincaid, and Robert F. Wagle, Department of Watershed
 Management

Objectives: 1. To determine transpiration rates of selected herbaceous and
woody species.

2. To correlate transpiration data with morphological,
physiological and environmental factors influencing said plants.

Procedures: Plants will be placed in a plexiglass chamber of known volume.
The pot will be enclosed in a plastic bag sealed around the stem of the
plant. Air will be circulated through the chamber by a small electric fan.
The temperature and humidity will be recorded inside the chamber by a
sensing element attached to an AMINCO temperature and humidity recorder.
After the temperature and humidity have been equilibrated, they will be held
constant by regulating water through a coil around the air stream and by
adding dry air from a compressed air tank. By measuring (through a flow
meter) the amount of dry air added, the amount of water transpired by the
plant can be calculated.

The transpiration rates of each species under a variety of temperatures,
humidities and light intensities will be recorded along with morphological,
physiological and environmental factors.

Progress: A device suitable for measuring transpiration (consisting
essentially of a plexiglass chamber equipped with an electric hygrometer)
has been designed, constructed and calibrated in the laboratory. Trans-
piration rates of four plant species have been measured under controlled
conditions of humidity and temperature.

Title: SURFACED RUNOFF BASINS AS A SOURCE OF STOCK WATER ON SEMIARID
 RANGES

Leaders: Ervin M. Schmutz, Department of Watershed Management and
 Richard J. Shaw, Department of Agricultural Engineering

Objectives: 1. To determine the feasibility of constructing low-cost,
surfaced runoff areas to collect precipitation for livestock water.

2. To obtain construction and maintenance costs and durability
data on surfaced runoff areas.

3. To determine the effect of season of year, intensity and the
total amount of rainfall upon the quantity of water collected.

4. To investigate the use and costs of various materials to
reduce evaporation and storage losses.

Procedures: Asphalt, plastic film and other lining materials will be studied as to their durability under Arizona desert grassland conditions. Instrumentation to determine precipitation, amount of runoff and evaporation losses will be utilized to determine size of collecting areas, storage facilities required and relative effectiveness of materials.

Progress: The construction of certain low-cost surfaced runoff areas for the collection of precipitation for watering livestock and game was found to be feasible and practical. Both asphalt and concrete paved runoff areas are now being utilized successfully for this purpose. On the other hand Polyethylene and Polyvinyl plastics were found to be too short-lived for use in paving runoff areas.

Title: CONTROL OF NOXIOUS SHRUBS ON SOUTHWESTERN RANGES

Leaders: Ervin M. Schmutz, Department of Watershed Management
Robert F. Wagle, Department of Watershed Management

Objectives: 1. To study the influence of climatic factors, such as temperature, humidity, rainfall, and soil moisture on the effectiveness of mechanical methods of controlling cholla and pricklypear cacti.

2. To study conditions and factors that result in variable kills of burroweed by 2,4-D and to develop a consistent and effective method of control.

3. To determine the factors affecting control of turbinella oak by herbicides following burning.

4. To determine the factors influencing control of creosotebush, whitethorn and tarbush with herbicides.

Procedures: 1. Plants of cholla and prickly pear cacti will be chopped at intervals throughout the year to simulate cabling. Temperature, humidity, rainfall and soil moisture measurements will be recorded and correlated with the rooting and survival of cactus joints.

2. Plots of burroweed will be sprayed with 2,4-D ester (PGBE). Phenological, climatic and other physical data will be recorded and correlated with degree of kill. Various carriers, emulsifiers, surfactants, and physiological treatments, including gibberellic acid and fertilizers, will be tested for effect on kill.

3. Both hand and aerial applications of various herbicides will be made on fire sprouts of oak chaparral.

4. Objective 4. Basic mixtures of 2,4-D and 2,4,5-T will be sprayed at intervals throughout the year to determine season and conditions of greatest susceptibility. Other chemicals, various carriers, emulsifiers, and surfactants will be tested for their effect on the absorption, trans-

location and toxicity of herbicides. Growth stimulants, fertilizers and various mechanical treatments will be applied prior to or simultaneously with the herbicides to test their effect on increasing the kill by herbicides.

Progress: 1. Cholla and prickly-pear. Readings on cholla sprouts following chopping confirm the two period, October-December and May-June, as the best months for mechanical treatment of cholla.

Sprouts established during these periods varied from 200-300 per acre, approximately the same density as originally. Highest sprouting occurred when chopping was done in the periods, February-April and July-August. Sprouts during these periods were initially as high as 6,000 to 7,000 per acre but, after three years, natural death had reduced these numbers to between 300 and 700 established plants per acre.

2. Burroweed. Project inactive at present.

3. Oak Chapparral. Results of two-consecutive-year airplane applications of 1-2 $\frac{2}{3}$ lbs. per acre of 2,4,5-T herbicides on turbinella oak resulted in 10-30% total kill as compared to 0-8% kill from a single application. Hand spray applications to individual plants resulted in 8-20% kill from a single-year one-pound application and 40-65% kill from two-consecutive-year one-pound applications. Preliminary results from tests with monuron, PBA and fenuron indicate promise at heavy rates.

4. Creosotebush, Tarbush and Whitethorn. The 1958 tests with both 2,4-D and 2,4,5-T resulted in unusually high, 90-100% kill on all three shrubs at the 2 and 8 lb. rates, showing marked year to year variation. Even the 1/2 lb. rate test gave 80% kill on resistant creosotebush. Granular herbicides, monuron and PBA, gave 40-70% kill at the 8 lb. rate but less than 10% at the 2 lb. rate. Radioisotope studies on creosotebush showed an expected close correlation between seasonal absorption-translocation and percent kill.

Title: GROWTH VARIATION IN QUERCUS TURBINELLA GREEN AND ITS RELATION TO ENVIRONMENT

Leader: Robert F. Wagle, Department of Watershed Management

Objectives: 1. To obtain fundamental information on genetic variation in woody plants using seeds and seedlings of the same species from different sources of origin.

2. To apply knowledge of environmental factors influencing genetic-physiological germination responses, plant establishment and plant growth responses to shrub control as follows:

a. To apply herbicides: (1) to seedlings of different origin in the laboratory, and (2) to mature plants of different origin in the field and interpret results in terms of plant variation and environment.

b. To correlate existing and future data on the herbicidal control of Q. turbinella with growth responses observed in seeds and seedlings of specific origin.

c. To develop new methods of controlling woody shrub distribution by testing the response of seeds and seedlings in different soils by: (1) adding micro-nutrients, and (2) adding macro-nutrients.

Procedures: Designed to meet the objectives stated above.

Progress: The soils studied thus far have exhibited some of the following characteristics:

1. Soil texture in general was coarse. Gravel and rocks made up 20 to 40% of the sample weights. The sand content of most samples was above 20%. The silt content of most samples ranged between 14 and 22". The clay content of most soils fell between 4 and 15%.

2. Chemical and bioassay results compared favorably on soil nitrogen content, but differed greatly as an index for available soil phosphate.

3. Certain vegetation soil relationships were indicated. Areas with the highest amount of grass exhibited nitrogen deficiencies, but no phosphate deficiencies - soil pH varied from 6.7 to 8.0. Soil from shrub-covered areas showed nitrogen deficiencies in five of ten samples. In all but one soil the nitrogen deficiencies were associated with a high CaCO_3 content - soil pH ranged from 6.2 to 8.0. Soil samples from woodland areas (ponderosa pine) showed no nitrogen deficiencies, but phosphate deficiencies were present in the two soils tested-- soil pH values were 6.0 and 6.7.

Title: SHRUB INVASION-FORAGE PRODUCTION INTER-RELATIONS ON ARIZONA RANGELANDS

Leader: David G. Wilson, Department of Watershed Management

Objectives: To determine site characteristics that may affect potential shrub invasion and forage production.

Procedures: Adjacent areas, climatically similar and under the same past and present management practices, but differing in degree of shrub infestation will be chosen for study. Vegetation differences will be determined. Soil characteristics will be determined for use in interpreting variations in degree of shrub invasion.

When adequate facilities are available, seed of the shrub species pre-dominating on each site will be germinated in soils from different sites and grown for one year. An attempt will be made to correlate observed germination, establishment, and growth differences with soil differences.

Progress: Final species composition and density measurements were made on a five-year study of forage production following removal of burroweed and all shrubs.

Soil separate analyses and chemical analyses were made on soil samples collected on invaded and uninvaded rangelands on the Santa Rita Experimental range. Efforts were concentrated on the Whitehouse gravelly sandy loam.

Future Plans: Field investigations will be concentrated on the shrub invasion-forage production interrelations in the Chaparral type.

Title: DRYLAND LEGUMES FOR SOUTHWESTERN RANGES

Leader: D. G. Wilson, Department of Watershed Management

Objectives: To test the adaptability of a number of dryland legumes under range conditions.

Procedures: Tests on the adaptability and maintenance potential of newly introduced types of forage-producing legumes with known or suspected drought resistance will be made. Critical factors of environment - edaphic, micro-climatic and biotic - will be studied to determine plant adaptability relationships.

Progress: A very limited number of P.I. introductions has shown some promise in this area. Medicago spp. from Afghanistan have survived the longest under the study conditions.

Future Plans: This project is being discontinued and work along this line will be conducted as a part of Reseeding of Arizona Ranges project.

Title: A COMPREHENSIVE STUDY OF THE LIVESTOCK POISONING PLANTS OF ARIZONA

Leader: D. G. Wilson, Department of Watershed Management

Objectives: 1. To determine the botanical, chemical and clinical nature of Arizona plants which are known or suspected as being toxic to livestock.

2. To prove or disprove the presence of toxic materials in certain plants which are usually recognized as being desirable forage plants for livestock.

3. To determine methods of range management which will be of aid in the control and/or prevention of livestock losses from poisonous plants.

4. To publish the results of this project in a publication describing the poisonous species, their field and clinical symptoms.

Procedures: Plant collections will be made for botanical identification; ecology of each species will be studied; chemical analyses of suspect plants at varying stages of growth; and if possible, clinical studies of the animal systems affected by toxic substances.

Progress: Investigation of losses from plant poisoning have been made as they are reported. The distribution and occurrence of many poisonous species in Arizona has been compiled.

Title: ECOLOGICAL EFFECTS OF FERTILIZERS ON DRYLAND RANGES

Leaders: Staff

Objectives: To determine the effect of dryland range fertilization on (1) botanical composition, (2) plant succession, (3) phenology, (4) length of growing season, (5) length of grazing season, (6) seed production, and (7) forage production.

Procedures: Phenologic data will be collected at periodic intervals during the growing season. A floristic analysis of the vegetation will be made at the end of each growing season. Quantity of forage produced will be determined periodically during the growing season and at maturity. Soil samples will be collected periodically and analyzed for soil moisture and residual fertilizers. Climatic data will be obtained on or adjacent to the study area.

Progress: Observations and measurements were made to determine residual effects of fertilization on two study areas treated in 1958 on the Santa Rita Experimental Range. Data on color, regrowth following over-utilization, relative height growth, time of flowering and seed set was secured.

It was noted that species composition changes occurred on the Holt study plots due to very heavy utilization of the relatively small plots. Annual grasses were more prevalent on the plots fertilized at the higher rates.

CALIFORNIA

Title: BIOLOGICAL CONTROL OF PUNCTURE VINE, MEDUSA HEAD AND WEEDY THISTLES

Leaders: C. B. Huffaker, J. K. Holloway, R. L. Doutt, and C. E. Kennett

Objectives: Locate in foreign countries insect enemies of above plants; test for specificity in feeding habits; introduce and establish in State and other interested states the species proven; accomplish control of those weeds here; and evaluate results.

Progress: During the last six month period preparations have been made to send a botanist to Europe to study the distribution and learn the best sites for later studies of the insects which attack puncture vine, medusa head and weedy thistles, with puncture vine largely excluded for the present.

Outside the formal scope of this project, but vitally a part of it, the USDA has reported much progress toward obtaining clearance to send us two species of weevils, Microtharidus spp. which attack puncture vine in Eurasia. It is hoped that these can be introduced in California next year. The California State Department of Agriculture has the proposal under advisement at present.

Future Plans: Exploration in Europe to establish distribution of subject weeds in Europe to facilitate future work and handling of insects probably to be introduced for control of puncture vine.

Title: ECOLOGICAL BALANCE IN RANGE SPECIES AS INFLUENCED BY MANIPULATION OF ENVIRONMENTAL FACTORS INCLUDING FERTILIZATION, SEEDING ADAPTED SPECIES AND LIVESTOCK USE

Leaders: Milton B. Jones, William A. Williams, and Horton M. Laude

Objectives: To learn (1) evaluation of forage, production and livestock gains on range seeded with perennial and annual species and unseeded range, (2) effect of livestock manipulation on maintenance of stands, (3) characterization of range microclimates.

Progress: Data from the third and final year of a grazing experiment indicated that fertilized pastures produced 3.2 times as much forage per acre, 2.5 times as much lamb per acre, and 6.4 times as many sheep days per acre as the resident range. Plot studies indicated that 40 pounds of applied N reduced the N content of the range plants at maturity, but 160 pounds of N increased it. Carry-over of 160 pounds N into the second year was measured.

N applied in September produced more forage than N applied during the winter or spring months. More N leached from fallowed soil than soil where soft chess or rose clover was growing. The effect of fertilization on botanical composition as it relates to clipping and grazing was studied. The application of gibberellic acid generally increased plant height and sometimes increased plant weight. Clipping brush from May to July reduced the regrowth of sprouts most. Starch content of the plant woody tissue dropped during this period.

Feed analysis and digestion trial data on rose clover indicate that it is about equal in feed value to alfalfa at a comparable stage of growth.

Pelleting of subclover seed with limestone was tried in four field experiments as an aid to Rhizobial inoculation on acid soils. A positive inoculation response was obtained on all four soils (range of pH 4.6 to 6.0), but the lime-pelleting was of questionable benefit. However, lime-banding increased stand and growth significantly on the soil with the lowest pH.

Title: INFLUENCE OF ENVIRONMENTAL FACTORS AND STRESSES UPON PHYSIOLOGICAL RESPONSE, GROWTH, AND PHENOLOGICAL BEHAVIOR OF FORAGE, RANGE, AND BRUSH SPECIES

Leaders: Horton M. Laude. Cooperating with C. M. McKell, Agricultural Research Service.

Objectives: Determine effect of: (1) temperature, moisture, light, soil, and the animal or biotic factor, (2) climate and microclimate as related to nature, frequency, and severity of stresses, (3) factors and stresses on chemical composition and functioning, (4) conduct phenologic studies of germination, emergence, persistence, flowering, seed development, maturation, and growth cessation.

Progress: 1. Regrowth of chamise sprouts following cutting has been studied in relation to stored reserves in top, crown, and root. Starch content of the root at the time of cutting appears to be a reliable indicator of sprouting ability. Poorest recovery in chamise occurs following cutting in May to July when starch is at the lowest level. Heavy browsing by deer or periodic mowing, both of which reduce stored reserves of starch, have affected regrowth according to the degree of starch depletion.

2. Heat stress on seedlings of red brome when of 7-day duration or longer reduces plant height, amount of tillering, amount of heading, and seed viability. Exposures to 90° - 95°F of plants between emergence and four weeks of age produced these results. Older plants brought into head under 90°F stress produced no viable seed. When removed from the stress later developing tillers headed and matured seed of greatly reduced viability. Such behavior suggests an important relationship between heat stress and forage production and natural reseeding.

3. Results from the study of high temperature and medusahead seed germination indicate a significant reduction in germination as seed moisture content increases. Application of research findings to control medusahead indicate the desirability of burning stands of medusahead before seed has dropped and while seed moisture percentage is still high. At this time associated range species have already matured and dropped their seed.

4. Poor clover years may improve by increasing phosphorus fertility. Several annual legumes, including important species used for reseeding, respond in top growth to increased phosphorus fertilization at low temperatures. Root growth also increased on the same species when phosphorus was increased.

Title: ANATOMICAL AND PHYSIOLOGICAL RESPONSES OF WOODY SPECIES TO HERBICIDES

Leaders: O. A. Leonard and A. L. Johnston

Objectives: To (1) study toxic action of chemicals on woody species in relation to plant structure, age, seasonal growth and environmental factors; (2) make physiological studies for species tolerance, mechanics of absorption, translocation into roots, and biochemistry of killing action, and (3) make exploratory work with new materials.

Progress: Since Dr. Leonard has been on sabbatical leave this last year in New Zealand, the work done on this project has consisted mostly of putting out extensive series of tests of newly formulated, granular or pelleted herbicides such as 2,4-D and the substituted ureas on various brush species, testing the translocation of phenoxy herbicides applied at different times throughout a season to branch tips of poison oak, and testing the effectiveness of phenoxy herbicides alone and with amino triazole on live oak sprouts throughout a season.

Title: NUTRITIVE VALUE OF SPECIFIC RANGE FORAGE SPECIES AS INFLUENCED BY SEASONS, FERTILIZATION AND MANAGEMENT

Leaders: G. P. Lofgreen, D. T. Torell, W. C. Weir and W. A. Williams

Objectives: To learn (1) techniques for measuring consumption. a. esophogostomy, b. clipping, c. hand selection, d. reference substances lignin, chromic oxide, chromogens, (2) nutritive value of specific range species. a. chemical composition, b. digestibility, c. mineral availability, and d. fiber utilization.

Progress: Techniques for measuring consumption of grazing animals have been studied extensively. These include the tritium dilution technique for determining the moisture content of consumed forage; a statistical study to determine the design which should be used for utilizing esophageal fistulated

sheep for collecting forage; a comparison of chromogen, chromic oxide and lignin ratio as indicator methods for determining consumption and digestibility; the chemical composition of forage collected by fistulated sheep compared to that obtained by hand clipping; the seasonal preference of fistula sheep for various species of range forage. Characteristics of specific species. Digestibility and consumption trials were conducted at Lincoln, Placer County, on rose and subterranean clover, at Hopland on chamise sprouts and native range--fertilized and unfertilized. An attempt to establish a pure stand of Harding grass is underway.

Title: BIOLOGY AND ECOLOGY OF RANGELAND GRASSHOPPERS

Leaders: W. W. Middlekauff and G. D. Kelly

Objectives: 1. Make an intensive ecological study of a limited rangeland area inhabited by several of important rangeland grasshoppers.

2. On basis of study, analyze and evaluate roles of various ecological factors in population dynamics of rangeland grasshoppers in area.

3. Use information in helping better understand population dynamics of range grasshoppers, to predict grasshopper damage to rangelands, and to develop more effective and intelligent control measures.

Progress: Studies on the bionomics of Melanoplus devastator and Dissosteira spurcata on California rangelands were continued. The life history of D. spurcata has not previously been elucidated. A sarcophagid parasite of grasshoppers, Sarcophaga falciformis materially reduced a heavy population of M. devastator to a non-economic level. Life history studies revealed that the female fly inserts a maggot into the muscles of the jumping leg. The maggot migrates into the thoracic cavity killing the host in six days.

Title: FACTORS IN WATERSHED MANAGEMENT THAT INFLUENCE THE DISPOSITION OF PRECIPITATION AND YIELD OF WATER

Leaders: A. F. Pillsbury, John Letey, Jr., O. R. Lunt, R. E. Pelishek, E. H. Taylor, P. B. Rowe, R. A. Merriam.
Cooperating with J. H. Patric, U. S. Forest Service

Objectives: Study factors influencing precipitation disposition with emphasis on vegetation management as a means of increasing water yields.

Progress: Work heretofore reported under this project, i.e. development of techniques to study subsurface moisture movement and storage, and watershed paving is this year being transferred to project H-1108A. Two new lines of endeavor are now being followed:

a. Soil temperature and transpiration. Differing effects of soil temperature extremes (particularly low temperatures) on watershed vegetation transpiration is a factor in watershed management not now evaluated. Various species will be propagated in the greenhouse, and then placed in controlled environment chambers with independent control of root temperature. The effect of temperature on transpiration of each species will be determined.

b. Evaluation of certain factors affecting water entry into soil. Initial work now being undertaken is a study of detention of precipitation in litter as a factor in prolonging the period of infiltration opportunity. This is being determined with layers of several types of litter in a constant temperature laboratory. Variables include depth of litter and slope. Characteristics of lateral flow and quantitative detention storage are being evaluated. Desorption curves for 2 types of litter from bush covered watersheds have been completed.

Title: EFFECTS OF RANGE MANAGEMENT ON INFILTRATION, RUNOFF AND EROSION

Leaders: A. F. Pillsbury, R. E. Pelishek, J. F. Osborn.
Cooperating with P. B. Rowe, Robert Merriam and Jim Patric, U. S. Forest Service

Objectives:

1. Develop improved devices and techniques for hydrologic studies.
2. Learn relation between precipitation intensity, runoff rates, and erosion rates through range improvement program.
3. Develop formulas for estimating magnitude of flood discharge.
4. Learn effectiveness of new vegetation in erosion control.
5. Effects of fire on infiltration rates of soils.
6. Hydrologic effects of various grazing practices used in management programs.

Progress: a. Plastic sheeting. 8 mil black vinyl sheeting completely deteriorated quite suddenly after a little over 3 years exposure. 8 mil black polyethylene sheeting is still in service. Plots established to see if material would prevent regrowth of phreatophytes were destroyed by others before results were obtained.

b. Subsurface moisture regime and movement. Considerable time was spent in attempting to place d/M meter access tubes in colluvial soil material (many rocks and boulders). All possible techniques, utilizing the rotary drilling equipment available, were tried without success. No percussion drilling equipment has been available. Drilling of the access tube holes was part of technique being developed for study of subsurface moisture movement to and from canyon bottom watertables.

The information obtained to date on subsurface moisture regime using the neutron scatter moisture meter has been of good quality but not particularly useful because of lack of sufficient precipitation to wet down more than 2 to 4 feet.

Title: BRUSH SEEDLING ESTABLISHMENT AND GROWTH IN RELATION TO SOIL FERTILITY LEVELS

Leaders: A. M. Schultz, R. Q. Landers; R. M. Love, J. Vlamis - cooperators;
H. H. Biswell

Objectives: To determine (1) if brush increase is related to soil fertility level; and (2) to what extent brush can be controlled by increasing soil fertility through fertilization.

Progress: Soils were taken from sites where a sharp line separates brush from grassland. On either side of this line parent material, slope and aspect are identical - only the vegetation differs. Ryegrass, wedgeleaf ceanothus seedlings, tomato, lettuce, and barley were grown on the soils in fertility pot tests.

Responses of brush seedlings to phosphorus were low compared to those of other plants. Responses to nitrogen were only slightly lower than those of other plants.

All soils were low in nitrogen. The brush soils were lower in available nitrogen but higher in phosphorus than the corresponding grassland soil.

Title: RANGE PLANT NUTRITION, RANGE SOILS, AND RANGE FERTILIZATION

Leaders: M. B. Jones, W. A. Williams, C. M. McKell, A. D. Haig, B. Kay,
R. A. Evans, V. P. Osterli, W. E. Martin and J. Vlamis

Objectives: 1. To increase our knowledge of the mineral nutrition of range species, both resident and seeded.

2. To relate forage production and the uptake of mineral nutrients to soil fertility as measured by chemical tests of soil and plant materials.

Progress: This is a new project just getting started and results have not yet been obtained.

Title: ECONOMIC ANALYSIS OF ADJUSTMENT OPPORTUNITIES IN RANCH MANAGEMENT ASSOCIATED WITH RANGE AND PASTURE IMPROVEMENT

Leaders: C. O. McCorkle, Jr., D. D. Caton, Lynn Rader and Charles Carpy

Objectives: 1. To evaluate selected range and pasture improvement practices under various ranching situations in California.

2. To develop economic guides for resource organization and management practices under representative feed and ranch resource conditions.

Progress: This is a new project just getting started and conclusive results have not yet been obtained.

Title: THE DEVELOPMENT AND HANDLING OF BROWSE SPECIES OF BRUSH FOR DOMESTIC LIVESTOCK USE

Leaders: H. H. Biswell, A. M. Schultz and L. DeBano

Objectives: 1. To learn if it is practical to seed and plant desirable browse species of brush for domestic livestock use.

2. To what extent brush stands can be improved and handled to increase their quality and their use by domestic livestock.

Progress: Analyses were made of the total nitrogen percent in leaves, stems and roots of two-year-old deerbrush plants grown in Holland soil where the plants were fertilized and unfertilized. Nitrogen percent was increased only slightly by fertilization. However, the weight of plants was increased several fold, for example, from about 6 grams, oven-dry weight per plant, to 40 grams per plant. The over-all result was an increase in total nitrogen percent about equal to the differences in weight of plants as given above.

Studies were made of the production of leaves and stems of one-year-old, and four-year-old deer brush plants that were transplanted to protected plots in the field. Weights were as follows: one-year-old plants; leaves 16 gm., stems 40 gm. In pounds per plant this would total .119 lbs. Four-year-old plants; leaves 342 gm.; stems 906 gms. In pounds per plant this would total 2.75 lbs. With plants spaced about 5 feet apart, the above weights would give a yield of about 200 lbs. per acre for one-year-old plants and nearly 5000 lbs. for four-year-old shrubs.

Title: EFFECTS OF BRUSH REMOVAL ON GAME RANGES IN CALIFORNIA

Leaders: H. H. Biswell, A. M. Schultz, R. P. Gibbens, and P. A. Jordan

Progress: Production of browse on a Madera County deer winter range at the end of four full seasons of growth following treatment was as follows: burned in early spring, 2,750 pounds per acre; mowed but unburned, 800 pounds per acre. An area burned in the fall produced 1,300 pounds per acre after three growing seasons. Brush seedlings contributed 46 percent of the total yield on the early spring burn, 32 percent on the mowed brush, and 79 percent on the fall burn. The number of brush seedlings surviving per acre on the areas were: early spring burn, 10,800; mowed brush, 2,500; fall burn, 34,900. During the winter months deer utilized 15, 25, and 18

percent of the total browse production on the early spring burn, mashed brush, and fall burn, respectively.

Brush seedlings fertilized with 300 pounds N and 300 pounds P per acre had an average leader elongation of 6.88 inches while that of unfertilized seedlings was 3.96 inches. The difference was highly significant. On the same plots fertilization increased grass production 146 pounds per acre.

Fertilization of mature wedgeleaf ceanothus plants on a 20-year-old burn in Madera County revealed a significant difference in utilization by deer between N, NS, NSP, and P treatments and the control. Utilization on the NS and NSP treatments was significantly higher than the N treatment. In percentage reduction of leader length the sulfur treatments were over 10 percent greater than the control and over twice as great as the P treatment. There was a significant increase in leader growth of both healthy and decadent plants on fertilized areas.

In ponderosa pine habitat in Lake County the emergence of ponderosa pine seedlings (1956 crop) on various seedbed treatments was as follows: Unburned, 1.2 percent; burned fall 1953, 1.1 percent; burned fall 1955, 9.8 percent; burned Oct., 1956, 12.0 percent; rototilled 1956, 18.3 percent; bulldozed summer 1956, 9.4 percent; raked August 1956, 25.8 percent.

Title: RANGE LIVESTOCK MANAGEMENT IN THE GRANITE AREA OF THE SIERRA FOOTHILLS, SAN JOAQUIN VALLEY

Leaders: F. D. Carroll, W. C. Rollins, G. P. Lofgreen and K. A. Wagon

Progress: Mr. James McDougald maintained the 50 cows from July 17, 1958 to July 7, 1959 as per agreement. The animals were maintained as a separate herd and in a condition equal to or better than at the San Joaquin Range. Due to the impotency of a University bull used to breed the replacement heifers in the group, only 84 percent of the cows proved pregnant. A 74 percent calf crop was weaned at an average weight of 513 pounds. Losses between pregnancy and weaning were due to causes similar to those previously occurring at the San Joaquin Range

The animals were moved to Davis in anticipation of using them as a foundation herd on a new range experiment station to be established east of Marysville late in 1959. This development did not take place, and the animals are presently being maintained on the University campus at Davis.

Title: MANAGEMENT PRACTICES TO IMPROVE CALIFORNIA RANGE LANDS

Leader: H. F. Heady

Progress: During the year the field studies were continued but time did not permit more than collection of data in field and laboratory and preliminary summarizing to the extent of recording the data in the same form used in previous years. Six specific phases of the research were as follows:

- A. Seasonal changes in species composition.
- B. Measurement of species composition, forage production and use on Watershed II, Hopland Field Station
- C. Effects of sheep and deer separately and together, and effects of sheep grazing continuously and in rotation in pastures on the Hopland Field Station
- D. Effects of mulch on range forage composition and production
- E. Forage preferences by sheep
- F. Effects of mulch on chemical characteristics of soil

Title: CONTROL OF RANGE WEEDS, BRUSH, AND PLANT COMPETITION BY FIRE, CHEMICAL, MECHANICAL, GRAZING AND OTHER MEANS

Leaders: B. L. Kay, C. M. McKell and O. Leonard

Objectives: Develop information on control of range weeds, brush, and plant competition.

Progress: Due to the seasonal nature of this work project reports will be on a July 1 - June 30 basis rather than January 1 - December 31. The material reported at this time was done under the Range Demonstration Project.

FLOURNOY RANCH - MODOC COUNTY

Total rainfall October 15, 1958 - June 15, 1959 was only 4.92 inches. The grazing trial was delayed on year due to drouth. Forage utilization by deer and antelope was greater on improved range than unimproved range, but was apparently due to the geographical position of the pastures rather than feed quality. Spraying sagebrush with 2,4-D resulted in up to 95% kill by the

third year after application. Forage response to carryover nitrogen was not observed, possibly due to the dry year. Repeated application of high rates of nitrogen fertilizer to resident ranges or wheatgrass seedings resulted in highly significant increases in early and total forage production with less than 5 inches of rain. Big bluegrass (Poa ampla) yielded almost three times as high as wheatgrasses (Agropyron sp) on this dry year.

WAGNER RANCH - HUMBOLDT COUNTY

Sub clover pastures established in 1954 from seed continue to indicate an increase in stand and outyield the resident range. Chemicals applied to hardwood stumps to prevent sprouting show Amine 2,4-D to be the cheapest and most effective. Fertilization of seeded perennial grass stands on "timber" and "grass" soils demonstrate the necessity of multiple clippings to correctly measure the relative response of seeded perennials and resident annuals.

PLANT COMPETITION REDUCTION WITH HERBICIDES

Competition between resident annual plants and seeded species was successfully reduced with pre-emergence chemicals during the 1957-58 growing season. Trials during the drier 1958-59 growing season were not successful.

Title: GRASSLAND ASPECTS OF THE SOIL-VEGETATION SURVEY

Leader: W. Robert Powell

Objectives: 1. Obtain data on existing herbaceous vegetation on specific soils to classify component species to their agronomic desirability.

2. Learn about responses to nutrients of resident and seeded species on individual soils.

3. Obtain land use history from ranchers and learn production of their ranges under management system used.

Progress: Grassland Vegetation Inventory. Inventory of grassland vegetation by soil series has been completed for Tehama County, continues for Humboldt County and has been started for Shasta County. The Field Manual outlining grassland sampling procedures was revised.

Greenhouse Nutrient Tests. One sample of Laughlin soil from Humboldt County showed a deficiency of N and P. Other samples of this series have showed deficiency N and S, and N, P, and S. One sample of Tyson soil from Humboldt County showed fairly high initial fertility but still responded to N, P, and S. Four samples of Yorkville soil from Humboldt County appeared deficient in N and P and one further deficient in S. One sample of Lodo soil from Glenn County responded to N, P, and S. Other samples have all responded to N and P and/or S. One sample of Contra Costa soil was deficient in N. One sample of Dibble soil from Tehama County was deficient in N. P. and S. Newville soil with which Dibble is intricately patterned does

not show the S deficiency. Two samples of Guenoc soil from Tehama County showed response to P and N, the N not showing except with P.

Field Nutrient Plots. Yield data for the Kneeland plot in Humboldt County indicates response to N and P. Treatment P caused an increase in native clovers, and treatment NP caused an increase in soft chess and perennial ryegrass. For the Yorkville plot in Humboldt County, yield data indicate a response to N. Treatment NPS caused a shift of grass species.

Lack of rain caused an early cessation of growth on the shallow Lodo soil plot in Glenn County. Scanty observations indicate that N, P, and S increase the yield. Treatment P favored native clovers and NPS favored ripgut.

Second year studies were made on Millsholm and Sehorn plots in Glenn County, yields from the latter showing substantial carryover due to sulfur.

Title: THE RESPONSE OF RANGE PLANTS TO VARIOUS TYPES OF GRAZING AND MANAGEMENT SYSTEMS

Leaders: J. E. Street, M. B. Jones, B. L. Kay and C. F. Walker.
Cooperating with C. O. McCorkle and D. T. Torell

Objectives: 1. Determine what system of sheep use results in the maximum benefit for grazing animals and the forage plants.

2. Conduct research on grazing as new plants, new fertilizers and fertilizer practices are used.

3. Conduct grazing experiments whereby some plant growth is controlled so as to encourage the better forage species; brush control by grazing should be exploited further.

Progress: Effect of Time and Intensity of Sheep Use on Unimproved Range. The sheep grazing phase of the experiment was started on October 29, 1959 with the weighing and distribution of 54 yearling wethers in the four experimental pastures. Before grazing 16 enclosure cages were set out in each of the four pastures.

Comparative Yield of Range Mixtures. For the third year of the trial three clipping and grazing dates were used, February 4, March 25, and May 25. Summation of these clippings indicate legumes alone gave highest yield followed by legumes + ryegrass; legumes + soft chess; legumes + Harding; and control the least.

Forage Production and Composition on Hopland Field Station. Average forage production on dry range for eight years averaged 1732.9 pounds per acre; 1958-59 growing season was 1711.8 pounds per acre. Composition indicated higher than average percentages of desirable annual grasses and filaree while lower than average percentage of undesirable annual grass, miscellaneous forbs, and native legumes.

Pasture Improvement by Use of Seeding, EPTC, and Grazing. With planting of annual legumes and using EPTC, legume percentage was increased along with forbs while annual grasses were decreased. Established harding was not reduced in density but was decreased in plant height with increasing rates of EPTC.

Grass-Clover Compatability Trials. As expected, annuals showed better initial stand than perennials when drilled into an old annual legume field. Two annual ryegrasses were significantly better than blando brome (*Bromus mollis*). Broadleaved plants (forbs) were the major component in the "annual type" pasture.

The reader is referred also to the 1958 Progress Report, Range Demonstrations, University of California Range Management Investigations. (This work is now included under the Agronomy Department's research projects).

COLORADO

Title: INDUCED VEGETATION OF DEPLETED RANGE AND ABANDONED CROPLANDS
TO INCREASE CATTLE AND SHEEP YIELDS

Leaders: A. C. Everson, Roy V. Miller, B. E. Dahl, Alfred Denham and
Herbert Mann. Cooperating with R. D. Barmington, Agricultural
Engineering Section, Colorado State University and Robert
Bement, Agricultural Research Service.

Progress: Studies are conducted at the following four locations: (1) Fort
Collins, (2) Central Plains Experimental Range, (3) Eastern Colorado Range
Station (Sandhills) and (4) Southeastern Colorado Branch Station. At each
of these sites uniform nursery trials are conducted.

At the Eastern Colorado Range Station near Akron, the following studies are
underway: blowout stabilization; cultural methods of seedbed preparation;
tests of various types of planting machinery; date of seeding; and tests of
various grass mixtures. At the Central Plains Experimental Range near Nunn,
tests are being made with various cultural methods for seedbed preparation
and with various types of planting equipment. In addition, the use of an
asphalt emulsion is being studied in conjunction with range seeding. At the
Southeastern Colorado Branch Station near Springfield, the following studies
are under way: (1) the inter-relations of soil moisture, fertilizer appli-
cations, and date of seeding on stand establishment and production of side-
oats grama and Russian wildrye; (2) comparison of various cultural practices
in the establishment of grass stands and (3) the effect of weed control during
the first year after planting upon the establishment of the grass seedlings.

Title: COLORADO COOPERATIVE GOPHER PROJECT

Leaders: R. M. Hansen and Terry Vaughan

Progress: Studies are being made on the habits of pocket gophers and their
relationships to rangelands and croplands, on methods of control, and on
their economic role.

Cooperative work with George Turner and James Keith of the Rocky Mountain
Forest and Range Experiment Station involves inter-relations of the pocket
gophers and cattle on Thurber fescue rangelands.

Cooperative studies with A. L. Ward and others of the Fish and Wildlife
Service involve control methods and food habits of pocket gophers. Of
particular interest has been the development of a burrow-builder which
appears to be a superior method for control of pocket gophers on agricultural
lands.

Title: THE USE AND MANAGEMENT OF SEEDED RANGE UNITS

Leaders: D. F. Hervey, B. E. Dahl, and Roy V. Miller

Progress: At Fort Collins six pastures of Russian wildrye and alfalfa are being grazed under one of the following plans: spring only, summer only, or spring and late summer. These pastures will be grazed during 1960 for the third consecutive year.

At the Eastern Colorado Range Station two 40-acre pastures of intermediate wheatgrass and two 40-acre pastures of intermediate wheatgrass with alfalfa will be grazed in 1960 with yearling cattle for the fifth consecutive year. Data are being collected to determine: (1) the diet of the grazing animals on the grass-alfalfa pastures during the various parts of the spring and summer grazing season, (2) the comparative weight gains of the animals on the various pastures, (3) the production and use on the various pastures, and (4) during 1958 nutritive content was obtained for the various forages throughout the growing season. Total forage production on the intermediate wheatgrass alfalfa pastures has been nearly double that on the intermediate wheatgrass pastures, and beef production has been in about the same ratio.

Title: IMPROVING SAGEBRUSH LANDS TO OBTAIN MAXIMUM RANGE LIVESTOCK PRODUCTION

Leaders: D. F. Hervey and Roy V. Miller

Progress: At the Great Divide Experimental Range in Northwestern Colorado, one phase of the study is concerned with an area set aside in 1956 to determine range improvement through: (1) deferment of depleted sagebrush range, (2) deferment plus mowing of the sagebrush, and (3) deferment with mowing and seeding to crested wheatgrass. During 1959 grass production increased sharply on the areas where the sagebrush was mowed. Yields of air-dry grass production for the three treatments were: (1) 66, (2) 216, and (3) 268.

In another phase of the study, pastures involved in sagebrush-burning tests were grazed for the seventh consecutive year with yearling steers and the herbicide-treated pasture was grazed for the sixth consecutive year. Average beef gains per acre on the various pastures were: untreated sagebrush, 7.5; sagebrush burned and pasture reseeded, 23.6; sagebrush burned, 11.4; and sagebrush treated with herbicides, 13.4.

Title: THE EFFECT OF FERTILIZERS ON THE SEASONAL TRENDS IN NUTRIENTS OF NATIVE AND RESEEDED FORAGE PLANTS IN RELATION TO RANGE LIVESTOCK PRODUCTION

Leaders: Charles Terwilliger, Roy V. Miller and Lloyd Washburn

Progress: At the Fort Collins Foothills Experimental Range, plots of Nordan crested wheatgrass were fertilized in the spring of 1958 with the following treatments: 0, 26.8, 53.6, and 80.4 pounds of available nitrogen per acre applied as ammonium nitrate. An equal number of plots were given the same treatment in 1959. The treated areas were grazed at the vegetative, boot, soft dough, and seed-ripe stage of plant development. Samples were taken to determine the current and carry-over effect of the various nitrogen applications on palatability, forage production, crude protein content, seed yield, and moisture content of the forage. During 1959 the carry-over effects of the 1958 treatment were determined, and in 1960 the carry-over effects of the 1959 treatments will be determined.

Palatability of the crested wheatgrass was improved with the heavier rates of nitrogen application, especially when the grass was grazed at the soft dough and seed-ripe stages. The carry-over effects of the nitrogen application in 1958 did not greatly influence the palatability of the crested wheatgrass in 1959 except with the heaviest rate of application, and in the first three growth-stages.

The moisture content of the herbage was increased in the vegetative and boot stages of growth by the application of nitrogen, but was lessened during the soft dough and seed-ripe stages. Thus, it appears that the increase in palatability during the late stages was not related to an increase in succulence.

IDAHO

Title: THE LIFE HISTORY, ECOLOGY AND CONTROL OF INSECTS ASSOCIATED WITH THE INTERMOUNTAIN SHRUB TYPE IN SOUTHERN IDAHO

Leaders: W. F. Barr, leader, Agricultural Experiment Station.
Cooperating with L. A. Sharp and E. W. Tisdale, Forest,
Wildlife & Range Experiment Station

Objectives: 1. To determine what species of insects are associated with the principal plants that make up the intermountain shrub type in southern Idaho.

2. Evaluate the role these insects play in the ecology of these range plants.

3. Study the ecology and life history of the insect species that effect the intermountain shrub type range plants.

4. Develop practical controls for those insects that have a harmful effect on the important plant species.

Procedures: Collections of all stages of insects that feed on or are associated with the various species of the intermountain shrub type. Permanent collecting stations have been established and general survey collections made. Evaluate the role these insects play in the ecology of the range plants by determining the type and degree of injury caused and the effect on each particular host as well as the effect on plant associations and plant stands. This is being done in conjunction with ecological studies on plants by range management personnel. Detailed studies on the ecologies and life histories of insect species of major importance are being made both in the field and laboratory. Control measures currently employed under Idaho conditions for related insects will be assessed against harmful species. Chemical, biological and cultural controls will be used, and where necessary, new methods will be developed.

Progress: Most of the common species of insects associated with intermountain shrub type plants have been determined and many new species of insects have been found. At present more than 200 species are known to be associated with range plants. Detailed life histories and ecologies of several species of major importance have been determined and studies are in progress on other species. In studies on harvester ants, it has been determined that rather large areas of rangeland are completely denuded. In good saltsage stands harvester ant clearings occupy approximately 3.5 per cent of the total area, whereas, in depleted saltsage stands these clearings make up 7.3 to 8.3 per cent of the total area. Excellent control has been obtained with granular applications of dieldrin, aldrin and heptachlor.

Title: STUDIES ON THE ECOLOGY AND PROPAGATION OF ST. JOHNSWORT INSECTS
IN IDAHO

Leaders: W. F. Barr, H. C. Manis, and C. I. Seely.
Cooperating with E. W. Tisdale, Forest, Wildlife and
Range Experiment Station

Objectives: 1. Determine if three new introduced species of St. Johnswort-feeding insects can become established in Idaho.

2. Conduct ecological and life history studies on all introduced St. Johnswort-feeding insects.

3. Determine the role each St. Johnswort-feeding insect will have in the control of this weed in Idaho.

Procedures: 1. Field releases, in selected areas that are ecologically different, of Chrysolina varians, Agrilus hyperici and Zeuxidiplosis giardi, and periodically check for successful establishment.

2. Conduct detailed ecological and life history studies on all introduced St. Johnswort insects in several ecologically different areas. Special attention will be given to such factors as temperature, relative humidity, precipitation, soil character and moisture, plant growth, fire, livestock trampling, parasites, predators and competition between species of insects. Data obtained will be used to determine the factors responsible for unsuccessful establishment, to delimit the areas where certain species can be expected to control St. Johnswort, and to make control plantings of the insects.

Progress: Five species of insects, Chrysolina gemellata, C. hyperici, C. varians, Agrilus hyperici and Zeuxidiplosis giardi, were introduced into various ecological areas in northern Idaho. Three of these, C. gemellata, C. hyperici and A. hyperici, have established themselves, but only C. gemellata has developed populations sufficient to reduce host plant stands over large areas of rangeland. However, even this species has not materially reduced stands of St. Johnswort in the Rathdrum Prairie area. Present data indicate that this is due to lack of synchronization of the beetle life cycle with plant development, the extremely hot dry soil conditions during the beetle estivation period and insufficient fall precipitation to produce early fall plant growth. It is hoped that the root-boring beetle, A. hyperici, will eventually build up in this area and effect control. It still remains to be seen whether C. gemellata can repopulate areas previously denuded of St. Johnswort and where now there is a marked resurgence of seedling plants.

Title: THE EVALUATION OF RANGE IMPROVEMENT PRACTICES IN IDAHO

Leaders: John A. Edwards, Agricultural Economics; L. A. Sharp, Range Management, Forest, Wildlife & Range Experiment Station

Objectives: To determine costs and benefits of range reseeding on southern Idaho sagebrush ranges.

Procedures: Data on costs and benefits of reseeding were obtained from a large number of case studies on both public and private lands.

Progress: An analysis of the profitability of range reseeding under different adjustment programs was completed. Assuming a 20-year life for the reseeded area, the price of beef at about 20 cents per pound, a re-seeding of 1,040 acres on a ranch consisting of 2,310 acres spring-fall range, 1,674 acres of summer range, would result in the following rates of return depending upon the method of adjusting to the temporary loss of range during the first four years:

<u>Alternative</u>	2%	<u>Rate of Discount</u>		
		4%	6%	8%
I	55.0	20.4	-5.4	-24.8
II	61.7	26.2	-0.3	-20.5
III	72.2	35.3	7.2	-14.2

Alternative I: Reduce breeding herd by 13 cows and 11 yearlings, rebuilding to original herd size by fifth year following seeding. Alternative II: Sell 24 calves each year for four years. Alternative III: Rent pasture for four years for 24 yearlings.

The findings of the above study indicate lower returns to reseeding than many previous studies have indicated. To the extent that a more realistic approach to the possibilities of range reseeding is encouraged, the above research will be of use to ranchers, public administrators and research workers in the field.

Title: STUDY OF MEDUSA HEAD ON IDAHO RANGES

Leaders: Minoru Hironaka.

Cooperating with E. W. Tisdale, Forest, Wildlife & Range
Experiment Station

Objectives: 1. Study the present medusa head infestation in Idaho and reasons for the present boundaries. The effects of climate, plant competition, soils and other factors will be evaluated.

2. Determine the changes in vegetation on medusa head infested areas brought about by means of various grazing practices and by protection from grazing.

3. Determine the variation in density and yield of medusa head and other annual species from year to year and relate these to climatic and other factors.

4. Study the influence of root development, litter accumulation, seedling establishment, etc., in the competitive relationships of medusa head with associated species.

Procedures: The autecology of medusa head is being studied by a combination of field, greenhouse and laboratory experiments. Competition of medusa head with other species is studied in both protected and grazed areas of range and on reseeded plots.

Progress: Considerable information has been obtained concerning the phenology and requirements of medusa head, especially in relation to those of cheatgrass (Bromus tectorum) with which it is mainly in competition in Idaho. Data on herbage production and on seed production and germination have been obtained under several site conditions and these data have been published. A study of the relative rate of the root development of medusa head, cheatgrass and two perennials, crested and intermediate wheatgrass, has been conducted and the results are now being prepared. The results indicate considerably more root elongation for both annuals during the winter than for the perennials, but with no significant difference between cheatgrass and medusa head in either rate or total amount of root development. The principal difference between the two species in root development lies in the later maturity of medusa head which is about three weeks later than cheatgrass in growth development. Studies of litter accumulation in medusa head and of its competitive effects on associated species are under way but have not progressed far enough to yield infinitive results.

Title: BEEF CATTLE NUTRITION ON SEEDED AND NATIVE FORAGE IN IDAHO

Leaders: Keith Lehrer, Department of Animal Husbandry and A. C. Wiese, Department of Agricultural Chemistry.
Cooperating with L. A. Sharp, and E. W. Tisdale, Forest, Wildlife and Range Experiment Station

Objectives: 1. To determine the nutrient content, total digestible nutrients, and digestible energy of forage consumed by cattle when grazing at different intensities and seasons of use on:

- a. Seeded areas (primarily crested wheatgrass)
- b. Native forage or unseeded areas

2. To determine the effect of intensity of grazing on nutrient intake and livestock production, i.e., weight, calf crop, grade, etc.

Procedures: The facilities of the Point Springs experimental pastures are used for the study. Forage production, utilization and chemical composition are studied intensively on small pastures. The weight gains of small lots (3 to 5 head) of experimental cattle using these small pastures are recorded along with fecal and urine samples. Total digestible nutrients, digested energy and carotene intake are measured and calcium, phosphorus and magnesium balances obtained. The lignin ratio technique is used to determine digestibility of the different nutrients. Salt and water consumption of the animals are recorded and activity studies made periodically.

Progress: The studies this year were devoted to completing the chemical and statistical analysis of data accumulated during the previous year. In addition, digestibility determinations were made. A summary of findings indicated: (1) Digestive energy was supplied to adequate amounts during both the spring and fall grazing seasons; (2) crude protein content of the forage was inadequate according to NRC standards for wintering yearling cattle during the fall grazing season; (3) phosphorus content of crested wheatgrass

was insufficient to meet the minimum requirements for cattle in the fall season; (4) ample quantities of calcium were present in both the spring and fall season; (5) total digestible nutrient values varied. These data indicate that supplemental feeding of phosphorus and protein is recommended on crested wheatgrass during fall grazing.

Title EVALUATION AND IMPROVEMENT OF SALT DESERT SHRUB RANGES

Leader: L. A. Sharp, Forest, Wildlife and Range Experiment Station

Objectives: 1. To determine the basic communities constituting the salt desert shrub type in Idaho with the climatic soil factors responsible for each.

2. To determine practices for the restoration of depleted salt desert shrub communities, particularly those which halogeton has invaded.

Procedures: The composition of salt desert shrub stands in Idaho is being studied by means of a large number of permanent transects and other sample plots. Both relatively undisturbed and successional communities are investigated. The climatic and soil conditions associated with these communities are being studied in detail, along with the effects of various degrees of grazing pressure and of other biological factors such as insects and disease. Studies on the life histories and suitability for reseeding of six native species have also been initiated.

Progress: A large amount of information has been accumulated on the life history and requirements of halogeton and its competitive ability in relation to other annual and perennial species. Long-term studies on permanent transects have shown marked fluctuations in both annual and perennial populations in salt desert shrub communities, as a result of changes in grazing pressure, seasonal climatic conditions and other factors such as insect attacks. Studies of the life history of the six forage species mentioned above have been under way for only one year and no definitive results are yet available.

Title: EVALUATION OF RANGE RESEEDING ON SAGEBRUSH RANGES

Leaders: L. A. Sharp, Forest, Wildlife and Range Experiment Station.
Cooperating with T. D. Bell, Department of Animal Husbandry

Objectives: To determine the production, persistence and response to grazing use of reseeded ranges in the sagebrush zone of southern Idaho.

Procedures: This project is conducted along two main lines. The first involves a detailed study of the reseeded vegetation on a large number of reseeding projects on both public and private lands. On each of these stands the cover, persistence, vigor and production of the reseeded species is evaluated over a period of years in terms of site potential and grazing use. These studies provide a fairly wide range of habitats and management practices as well as reseeding methods.

The second portion of the project involves a controlled grazing study of a crested wheatgrass stand established by the Bureau of Land Management in the Raft River Valley near Malta, Idaho. Here the reaction of the reseeded stand to 3 intensities of grazing including spring only, fall only, and spring-fall use are being studied. The results are being evaluated in terms of effects on the vegetation and gains of cattle. Salt and water consumption by live-stock are also being measured in these experiments.

Progress: Plant cover, yield, composition and trend have been studied in 12 seedings which represent a variety of site conditions in south central Idaho. The effects of seasonal climatic fluctuations and of insects and other biotic influences, as well as grazing, upon these stands are followed closely each year. The controlled grazing trials in the Malta area are providing specific information on the response of crested wheat seedings to definite amounts of utilization and likewise the response of the cattle to these conditions.

Title: ECOTYPIC VARIATION IN IDAHO RANGE SPECIES

Leader: E. W. Tisdale, Forest, Wildlife and Range Experiment Station

Objectives: To determine the degree of variability within important Idaho range species and to determine the ecological status and relationships of such races. At present the work is being confined to the genus Festuca with emphasis on F. idahoensis, an important and widely distributed range species. Some work is also being done on closely associated species of native perennial fescues.

Procedures: The procedures involve collection of seed or sod material of the species involved from representative habitats over as wide an ecological and geographical range as possible. This material is brought together and grown in uniform gardens; the principal one of these is located on the University of Idaho campus at Moscow, but a great deal of the material has also been planted in the gardens of the Carnegie Institution of Washington, Stanford University. Observations on the survival, growth development, vigor and productivity and morphological characters of the planted materials will be made in an effort to distinguish the degree of intraspecific variability.

Progress: This project was not begun until the summer of 1958, and progress to date has consisted mainly of the establishment in the two nurseries mentioned of 25 cultures including a number of collections of F. idahoensis and one to three collections each for F. rubra, F. occidentalis and F. scabrella. Observations on this material to date indicate marked differences in survival, both initial and winter, in size and vigor of individual plants, and in color and fineness of leafage as well as time of flowering and extent of culm production.

Detailed observations will be continued on the material already in the nurseries and additional cultures added to round out the study of F. idahoensis.

Title: ECOLOGY AND CONTROL OF GOATWEED (HYPERICUM PERFORATUM)

Leader: E. W. Tisdale, Forest, Wildlife and Range Experiment Station, Department of Range Management and W. F. Barr, Department of Entomology

Objectives: 1. To study the ecology of Hypericum and its competitive ability on different sites.

2. To determine the successional changes occurring on areas where biological control practices are under test.

Procedures: Permanent study sites were selected to represent a variety of conditions within the area of Idaho infested by Hypericum. Altogether 25 of these sites were established and the vegetation sampled by means of permanent plots. Foliage and basal cover and frequency on smaller plots were the principal methods of measurement used for the vegetation. The soils of these sites were studied also and information obtained on climatic conditions. The majority of these sites were established simultaneously with the release of Chrysolina beetles, either C. gemellata or C. hyperici. Changes in the vegetational cover caused by the activities of these beetles have been determined by periodic re-study of the sample plots.

Studies of limited phases of the autecology of Hypericum were carried on in a few of these sites. Emphasis was placed upon reproductive characteristics and phenology. Seed germination and longevity, seed production, seedling survival and vegetative reproduction were all studied, as was the phenology under different site conditions.

Progress: The extensive stands of Hypericum which occupied former grassland areas in north central Idaho have been greatly reduced in the period 1950-1960 through the action of the Chrysolina beetles. This reduction has been so great as to virtually eliminate the weed from some of the study sites. On some of the first established sites, however, there has been a resurgence of Hypericum during the past two years, although the populations are still in the nature of 5 to 16 percent of those present prior to the beetle introductions. The progress of this resurgence and of the reaction of the beetles

still present in the area is being studied. On sites occurring on open forest stands or cut-over forest lands, the control of Hypericum by the beetles has been much less effective. Apparently the combination of habitat conditions does not provide as good synchronization between the life history of the beetle and the phenology of the Hypericum plant as occurs in the grassland areas. Studies of the autecological features of the plant have been essentially completed and published.

Title: ECOLOGY OF SAGEBRUSH GRASS RANGES IN IDAHO WITH SPECIAL REFERENCE TO VEGETATION SOIL RELATIONSHIPS

Leaders: E. W. Tisdale, leader, Forest, Wildlife & Range Experiment Station, Range Management, M. A. Fosberg, Minoru Hironaka, G. C. Lewis

Objectives: 1. To make a basic study of the vegetation and soils of the sagebrush grass range areas of Idaho, with the purposes of recognizing and analyzing the different habitat types (site types) comprising each major kind of range, and the factors responsible for their differences.

2. To determine the changes produced in vegetation and soils on these habitat types by the effects of grazing, fire, insects, erosion or other disturbing factors.

3. To evaluate the present and potential productivity of the various range habitat types recognized and thus provide a sound basis for management and improvement practices adapted to specific range areas.

Procedures: The basic procedure involves detailed study of a large number of samples of representative areas in the different kinds of sagebrush grass vegetation in the State. These areas are selected on the basis of being relatively free from disturbance by grazing or other factors, and as being representative in both vegetation and soils. Detailed characteristics of the vegetation including species present with foliage cover and basal area, frequency, and in some cases, herbage yields, are obtained on sample plots 50 x 100 feet in size. A detailed soil study is made at each of these sites and samples taken for laboratory analysis, including pH, organic matter, and exchangeable salts. To date this initial phase of the project has received most attention but study of changes produced by grazing or other factors are now being investigated, through the study of plots which have been exposed to these influences as well as through controlled field and laboratory studies.

Progress: To be found in the 1959 Annual Report for the Idaho Contributing Project to Regional Project W-25.

Study of the basic types of sagebrush-grass vegetation and associated soil will be continued until all the major types have been analyzed. Increasing emphasis will be placed on the study of changes produced in these types by various factors and of the reasons for the differences existing among the types.

Title: A STUDY OF THE ECOLOGY AND CONTROL OF HALOGETON

Leaders: Paul J. Torell and L. C. Erickson, Department of Agronomy.
Cooperating with Robert H. Haas, Agricultural Research Service.

Progress: The important halogeton research accomplished during the past year was concerned with three aspects: (1) testing commercially available formulations of the benzoic acids for pre-emergence halogeton control; (2) germination studies on saltsage (as a possible species to revegetate halogeton-infested ranges); and (3) studies on the longevity of halogeton seed.

Experimentation with benzoic acids showed the 2,3,6,-TBA formulation to be superior to the polychloro formulation. This was true on a rate per acre as well as a cost per acre basis. Two pounds active ingredient of the 2,3,6,-TBA formulation was necessary to give satisfactory halogeton control for one year.

Experimental plantings of saltsage on a desert and on an irrigated site did not provide a stand. Germination studies showed significant increases in per cent germination of saltsage seed by treatment with carboy concentrated sulphuric acid at 10, 20, and 30 minutes and by stratification in moist vermiculite at 38°F. for 30 days.

Seed longevity studies with brown and black halogeton seed showed that no viable black seed remained after two years in the field. However, the brown halogeton seed maintained good viability at the end of two years and sufficient seed remained to suggest viability will last at least three years. This finding will definitely complicate chemical control of the weed.

Future Plans: Herbicidal studies will be continued with emphasis on the use of 2,3,6-TBA. This herbicide has been applied at five rates and at five locations in Idaho. New herbicides will be screened for their effect on halogeton. Revegetation studies are being continued with saltsage.

Title: THE CONTROL AND ERADICATION OF WEEDS ON PASTURE AND RANGE LANDS

Leaders: P. J. Torell, L. C. Erickson, and C. I. Seely.
Cooperating with Agricultural Research Service.

Progress: Field and laboratory investigations on Medusa head control were conducted in Twin Falls and Latah counties and at the Home Station, Moscow. Field studies were intensified on methods of establishing desert wheatgrass in Medusa head infestations. These treatments included: 2 years of cultural and/or chemical treatments for weed control prior to reseeding, i.e., first year - moldboard plowing, disking, burning, 2 lbs. dalapon per acre. The second year all treatments were disced prior to reseeding desert wheatgrass. The best stands resulted from the burn plus disc, and the dalapon plus disc treatments. Plowing was not desirable. Chemical analyses studies revealed

that Medusa head is equal or better than downy brome grass in nutritive value at equivalent growth stages, but that Medusa head contained 13% silica while downy brome contained only 4%. This may account for the harshness and resistance to decomposition of the former. Annual surveys are continuing on the distribution, prevalence, and persistence of beetles with reference to cyclic control of *Hypericum perforatum*.

Future Plans: The research on medusa head control will be increased. The favorable reseeding treatments that have showed promise on small plots will be tried on large plots that will permit the use of large tractors, heavy plows and drills. Dalapon and other herbicides will be tested for the most efficient rates, dates, and spray volumes. Studies will continue on chemical composition and factors involved in vernalization.

Title: EVALUATION OF FORAGE SPECIES AND SEEDBED PREPARATION OF SOUTHERN IDAHO DRY LAND PASTURES AND RANGES

Leaders: Paul J. Torell, John Kolar, Alfred Slinkard

Progress: Forage nurseries were seeded at these four locations on dryland ranges in 1958: Raft River, Bliss, Shoshone and Emmett areas. These nurseries were evaluated for seedling stands in 1959. The important results were:

1. None of the forage grasses presently available are adapted to the saline soils of a saltsage community.
2. At the Bliss, Shoshone, and Emmett locations the wheatgrass species that make up the desert wheatgrass complex provided the best stands.
3. At these locations Nordan desert wheatgrass was significantly superior to Siberian wheatgrass for seedling stands.
4. Mountain rye was outstanding at the same locations for rapid growth and extreme vigor.
5. Fall planting at Raft River was inferior to spring planting in the number of seedlings emerging for most entries except Nebr. 3576. Fairway wheatgrass, giant wildrye and Mandan ricegrass. Heavy mortality was noted for all entries of the spring planting.

Future Plans: The nurseries established in 1958 will be evaluated for stand, vigor, and possibly yield in 1960. A new nursery will be seeded in the Emmett area to test variety adaptation to the ranges in southwestern Idaho and to ascertain their competitive ability against medusa head.

Title: PASTURE IMPROVEMENT

Leader: Kling L. Anderson

Objectives: To study and develop methods of bringing about improvement in pastures and in their management.

Progress: Range yields are reduced by burning, the earlier burning causing greater forage yield reductions. One cause is apparent, that of reduced soil moisture supply. Some shift in plant population may also play a part.

Forage yields of smooth brome are maintained at or near their highest practical levels by the use of nitrogen fertilizer sufficient to supply around 100 pounds N. per year. Heavier applications have not given sufficient greater increases to be practical.

Seeding major warm-season native grasses in March or April results in better stands than either in earlier or later plantings.

Uniform trials with accessions of major grass varieties are being shifted from clipping alone to a combination of clipping and grazing.

Collecting accessions of major species of native grasses has exposed some of the wide variability that exists in natural populations and has made materials available for increase and for plant breeding use.

Title: EFFECTS OF DIFFERENT SYSTEMS OF MANagements OF GRASSLANDS AND CONSERVATION AREAS UPON INSECTS INJURIOUS TO GRASSES

Leaders: W. Harold Arnett and Herbert Knutson

Objectives: To determine the cause and extent of insects injurious to grasslands; to study the relationship between grassland insects and insects injurious to adjoining crops; to study life histories, habits, identification and control of grassland pests; and to observe grass species and selections for differential insect injury.

Progress: The third year of a study of insects found in bluestem pastures near Manhattan has been completed. Three pastures are in an intensity of grazing experiment, three in a deferred-rotation grazing experiment and three in a time of spring burning experiment. All except two of the pastures are stocked at a moderate rate. The two exceptions involve light grazing and heavy grazing. From May 8 to September 28, three range sites (clay pan or clay upland, ordinary upland, limestone breaks) within each pasture were

sampled by the sweep net method. The insects were identified to order and stored for further identification to species. Collections this season totaled 56,917 insects. The most important grass-feeding insects were the grasshoppers and leafhoppers which made up 40%.

Clay pan and clay upland sites supported the largest insect populations and limestone breaks supported the smallest populations. Leafhoppers were more numerous on the ordinary upland sites whereas beetles and grasshoppers were the most abundant in the clay upland sites. Beetles were more numerous in the lightly grazed and deferred pastures. Leafhoppers were collected about equally from all pastures. Grasshoppers were more abundant on the burned pastures and heavily grazed pastures.

Of the common crop-infesting grasshoppers, Melanoplus femur-rubrum was the most abundant. Most of the grass-feeding species were more abundant on the clay sites but the crop-feeding species of Melanoplus were more abundant on the ordinary upland sites. Largest populations of grasshoppers were found in the pastures under heavy grazing and early spring burning treatments and smallest in pastures under light grazing and deferred-rotation grazing treatments.

Identification of the species of Chrysomelidae collected in the past three years is being undertaken.

Future Plans: Identification of other families collected during the previous three years and their relative abundance on the various pasture treatments and range sites. Relationship of various grasshopper species to host plants and oviposition sites.

Title: WEED CONTROL WITH CHEMICALS

Leader: L. E. Anderson

Objectives: To find more effective methods of controlling weeds.

Progress: Included is work on weed control in seeding alfalfa. Only two years' work does not yet permit definite statements of results.

Title: MULTIPLICATION, PRESERVATION, AND DETERMINATION OF POTENTIAL VALUE OF FORAGE GRASSES AND LEGUMES

Leaders: Kling L. Anderson and F. L. Barnett

Objectives: To make preliminary appraisal of lines of forage plants and to preserve those of potential value.

Progress: From the many accessions grown and examined, the following material has some:

1. Isolation blocks for combining selected plants and material for the project on grass breeding.
2. Direct increase of superior plants alone or combined into strains. To date, these include Sorghastrum nutans, Andropogon gerardi, A. Scoparius, and Panicum virgatum.
3. Materials sent to the Peoria laboratory.
4. Superior lines deposited at the Ames, Iowa laboratory
5. Plants and lines have been made available to all interested plant breeders.

Further increase and testing is planned with major emphasis in the near future centered on Andropogon scoparius, especially lines of southwestern origin.

Title: SUDANGRASS BREEDING AND EVALUATION

Leaders: H. L. Hackerott and A. J. Casady

Objectives: Develop lines, including cytoplasmic male sterile ones and compare lines.

Progress: Although sudangrass-sorghum hybrids have been superior to sudangrass varieties in production, they lodged severely and have not been superior in yield to forage sorghum varieties.

Title: ALFALFA IN NATIVE GRASS MIXTURES

Leaders: H. L. Hackerott and E. L. Sorensen

Objectives: To compare alfalfa strains, their culture, and their relationships to native grass under dry land conditions.

Progress: Nine alfalfa varieties were grown in a mixture of blue grama, sideoats grama, and buffalograss. Stands of alfalfa were obtained two out of five years. Creeping types spread in grass stands. Forage yields were increased somewhat by the presence of alfalfa.

Title: EVALUATION OF RANGE GRASSES AT THE COLBY BRANCH EXPERIMENT
STATION OF KANSAS STATE UNIVERSITY

Leader: Wallace Harris

Objectives: To determine the comparative ease of establishment of various grasses. To determine yield potential of grasses under range conditions. To determine length of time stands will remain.

Progress: Adequate stands have been obtained more consistently with sand lovegrass and switchgrass than with others that have been tested. Buffalo-grass and blue grama have survived more vigorous droughts after they were established than other grasses but production potential was low compared to other grasses especially in years of adequate precipitation. Wheatgrasses have high yield potential when good stands are obtained and moisture is adequate but have been short-lived under drought conditions. No significant differences in yield between varieties of a species have been noted.

Title: ESTABLISHMENT OF FORAGES

Leader: Leonard Hertz

Objectives: 1. The effect of certain management treatments on the production of forage from an established stand of red clover.

2. The effect of certain cultural treatments on the establishment of red clover in oats and wheat.

3. The effect of certain herbicides on the establishment and early growth of alfalfa and red clover.

4. The effect of certain fertility and management treatments on the production of forage from an established stand of smooth brome.

5. The effect of certain management treatments on the forage and grain production of small grains.

6. Variety trials - grasses and legumes. Varieties of the following species are being compared: alfalfa, red clover, sweetclover, birdsfoot trefoil, tall fescue, smooth brome, wheatgrasses, orchardgrass, sudangrass and other forage sorghums.

Progress: These are relatively new trials and it is too early to draw definite conclusions from the limited results available.

Title: EFFECT OF GRAZING SYSTEM ON LIVESTOCK AND VEGETATION

Leaders: B. A. Koch, F. W. Boren, B. D. Carmack, E. F. Smith, and K. L. Anderson, Departments of Animal Husbandry and Agronomy

Objectives: To compare the following treatments on bluestem pasture; moderate stocking, over-stocking, under-stocking, and deferred-rotation grazing.

Progress: Results to date indicate over-stocking is reducing forage productions with increased production on the understocked pasture and possibly the deferred pastures. Animal gains have been reduced by deferred grazing and by heavy, season-long stocking.

Yields of bluestem grasses have declined under heavy stocking but have increased under light and under deferred-rotation grazing. Quantities of mulch have followed the same pattern. Greatest differences are seen on clay upland range sites and smallest ones on the break sites.

Light stocking has allowed some increase in grasses that are expected to decrease under grazing. Deferred-rotation grazing has also done this. It appears that the deferred-rotation pastures, now stocked at the "moderate" rate, are in fact, understocked.

Title: NUTRITIVE VALUE OF FORAGES AS AFFECTED BY SOIL AND CLIMATIC DIFFERENCES

Leaders: B. A. Koch, E. F. Smith, D. Richardson, C. S. Menzies, R. F. Cox, and M. M. McCartor

Objectives: 1. To measure, by animal performance, any differences in nutritive value of forages due to variations in fertility or other soil characteristics.

Progress: Native pasture forage and hay from limestone soil areas and sandstone soil areas have been studied. Cattle consuming forage from limestone soil areas apparently out-perform those consuming forage from sandstone soil areas. Supplemental phosphorus had no effect on performance. Supplemental trace minerals for cattle consuming forage from sandstone soil have shown some evidence of improving performance of the cattle. Further work must be completed before definite conclusions can be drawn.

Title: EFFECTS OF SEEDING DATE, SEEDBED COVER TYPE, AND QUANTITY OF MULCHING MATERIAL ON SEEDLING ESTABLISHMENT OF NATIVE PERENNIAL GRASSES

Leader: J. L. Launchbaugh

Objectives: 1. To investigate dates of planting, and quality and quantity of mulching residues as the influence seedling establishment.

2. To investigate the influence of various mulches and quantities of mulches on the environment of the seedbed.

Plantings of important native grass species including switchgrass, sideoats grama, big bluestem, and western wheatgrass will be made during each month of the year in sorghum cover. Seeding will be done at a shallow depth at the rate of 25 viable seeds per foot of row in rows one foot apart. Weeds will be controlled with a minimum of disturbance to the mulch cover. Quality and quantity studies will involve seeding the various species during late fall, mid-winter, and early spring in various types and amount of natural and artificially applied residues.

Environmental factors to be studied in relation to cover residue include soil moisture, soil temperature, relative humidity near soil surface, and light intensity at soil surface. These determinations will be made periodically during the year and frequently during the period of germination and emergence. These measurements will be compared with similar ones from bare soil and related to seedling performance.

Progress: Data for one year indicate that warm-season species were more easily established when planted in April and May. Western wheatgrass emerged best from the late fall-early winter plantings. There is nothing to report on the remaining phases of the project.

Title: EFFECTS OF COMMERCIAL FERTILIZERS ON RESEEDED GRASSES IN WEST-CENTRAL KANSAS

Leader: J. L. Launchbaugh

Objectives: 1. To determine the relative deficiencies of 'N, P, and K for important soils reseeded to grasses in the vicinity of Hays, Kansas.

2. To determine the effects of field applications of major elements on forage yields, species composition, and forage protein content of reseeded grasses.

3. To determine the carry-over effects of fertilizer applications.

During 1956, the upper six inches of eight different soils were used in greenhouse pot test analyses to determine relative nitrogen, phosphorus, and potassium deficiencies. Two sites for field applications of fertilizers were selected on the basis of the pot test analyses, one being typical of moderate to high fertility areas and the other typical of low fertility areas. Treatments consisted of 80 pounds N/acre alone, 60 pounds P₂O₅/acre alone, NP together, and an unfertilized check. The fertilizer treatments were topdressed in April, 1957, carry-over effect measured in 1958, and re-fertilized in 1959. Carry-over effect will again be measured in 1960. Sampling consisted of a mowed strip in each plot for yield determination, composition estimates, and protein samples collected during spring and fall.

Progress: The soils were divided into two distinct groups on the basis of greenhouse pot tests: (1) those that had a moderate to high nitrogen deficiency and a low phosphorus deficiency, and (2) those that had both high nitrogen and phosphorus deficiencies. There were no indications of a need for added potassium in any of the soils. Nutrient deficiencies were related to the degree of soil erosion on the various sites. Field applications resulted in significantly high yields from the N and NP treatments on both sites. On the low fertility site, NP gave a significantly higher response than N alone. Carry-over effects during 1958 were significant only on the low fertility site. Botanical composition was altered only on the high fertility site where annual brome grass was greatly increased by N and NP. During 1957, most of the increase in forage production was due to the increase in amount of annual brome grass. Crude protein content was increased significantly by the application of N and NP only during the 1959 season.

Title: EFFECTS OF VARIOUS MOWING AND BURNING TREATMENTS ON THE PRODUCTION OF NATIVE AND RESEEDED GRASSES

Leader: J. L. Launchbaugh

Objectives: 1. To determine the effects of old growth removal on forage production.

2. To determine the long-range effects of reseeded grasses under various mowing and burning treatments compared with cropping on the infiltration rate of an upland silty clay loam soil.

Treatments include: (1) fall burning, (2) fall mowing at various heights and raking, (3) spring burning, and (4) spring mowing and raking. Forage yields will be determined from mowed strips in the fall.

Progress: After two years of spring burning and spring mowing and raking, the undisturbed check plots in reseeded western wheatgrass produced only 37 per cent as much forage as the treated areas. Tiller numbers on the untreated checks were only 25 per cent as high as on the burned and mowed plots. There is no progress to report on the remaining studies in this project.

Title: THE EFFECTS OF CHEMICAL AND MECHANICAL WEED CONTROL ON
NATIVE RANGE VEGETATION

Leader: J. L. Launchbaugh

Objectives: 1. To investigate the economic feasibility of applying weed control treatments to native range in terms of effects on forage production.

2. To compare herbicide treatments with mowing treatments.

The following treatments were applied during 1959 to an upland shortgrass area with a relatively high infestation of western ragweed: (1) mow once at two inches when weeds are ten to twelve inches tall, (2) mow as necessary to keep weeds below ten to twelve inches, (3) spray once with 3/4 to one pound ester of 2,4-D per acre when weeds are six to eight inches tall, (4) spray as necessary to keep susceptible weeds under control, (5) a hand-weeded check, remove all weeds as often as necessary, (6) an unmowed, unsprayed check, and (7) an unsprayed check, mowed at the end of the growing season. Beginning in the second year, the plots treated the first year will be split. Retreatment will be applied each year on one part of each plot and every two years on the other part. At the end of each season, the entire area, except the unmowed check, will be mowed at approximately two inches to remove plant residue and make yield and species composition determinations.

Progress: During 1959, all treatments reduced the yield of weeds significantly but did not result in significant increases in grass production when compared with the untreated check plots.

Title: EFFECTS OF THREE INTENSITIES OF SUMMER GRAZING ON NATIVE
VEGETATION AND STEER GAINS

Leaders: J. L. Launchbaugh and J. R. Brethour

Objectives: To determine the effects of heavy, moderate, and light summer grazing on: (1) yearling steer gains, (2) ground cover and species composition of native vegetation, (3) forage yields, and (4) forage utilization.

Native shortgrass pastures, 30 to 35 acres in size, are grazed with yearling steers from May 1 to October 1 at the following rates in acres per steer: 2.07 (heavily grazed), 3.56 (moderately grazed), and 5.07 (lightly grazed). Cottonseed meal is fed at the rate of 1-1/2 pounds per head daily during August and September. The steers are weighed monthly following a 12-hour shrinkage. Vegetation studies consist of the following: (1) ground cover and species composition measurements each fall by the point system, (2) forage yield and utilization determinations by a caged and uncaged plot technique, and (3) random samples approximating grazed portions of the vegetation collected monthly for crude protein analyses.

Progress: Kansas Agricultural Experiment Station Bulletin 394 contains a summary of results from 1946 to 1957. Important conclusions to date are: (1) the lighter the stocking rate, the higher the individual steer gains, (2) the heavier the stocking rate, the greater the beef production per acre, (3) highest financial returns have resulted from moderate and light stocking, (4) the lighter the stocking rate, the lower is the amount of buffalograss and the higher is the amount of blue grama and western wheatgrass, and (5) during recent years, forage production has averaged 50.0% more under moderate grazing and 87.5% more under light grazing than under heavy grazing.

Title: EFFECTS OF THREE INTENSITIES OF WINTER AND SPRING GRAZING ON NATIVE VEGETATION AND STEER GAINS

Leaders: J. L. Launchbaugh and J. R. Brethour

Objectives: To determine the feasibility of wintering weaned calves on native shortgrass pasture in terms of gains and required supplementation, and to compare heavy, moderate, and light grazing from November 15 to July 1 with similar grazing intensities from May 1 to October 1 in terms of effects on the vegetation: (1) ground cover and species composition, (2) forage yields, and (3) forage utilization.

Native shortgrass pastures, 30 to 35 acres in size, are stocked at three rates depending on the amount of vegetation in each pasture on November 15. The goal in stocking is to utilize from 70 to 90 percent in the heavily grazed pasture, 40 to 60 percent in the moderately grazed pasture, and 20 to 30 percent in the lightly grazed pasture by May 1. The steers receive sorghum grain and a combination of cottonseed meal and alfalfa from November 15 to May 1 and none from May 1 to July 1. The rates of supplementation are varied each year in an effort to find the quantities needed to result in daily gains of $3/4$ to 1 pound per head during the dormant forage period. Steer gain determinations and vegetation studies are handled by the procedures outlined in project: Hays 254-A.

Progress: Since the start of the trials in 1957, steer gains have been nearly the same within years regardless of intensity of grazing. Levels of supplementation up to two pounds of sorghum grain, one pound of cottonseed meal, and three pounds of alfalfa hay daily have been insufficient to produce daily gains above $1/2$ pound during the dormant forage period. Gains during May and June (the green feed period) have been relatively low considering the low winter gains. The vegetation studies indicate that no significant changes in cover, composition, and yields have occurred during the last three years in comparison with similar vegetation grazed during the summer months only.

Title: COMPARISON OF COTTONSEED MEAL AND SORGHUM GRAIN AS SUMMER NATIVE PASTURE SUPPLEMENTS

Leaders: J. L. Launchbaugh and J. R. Brethour

Objectives: To compare the effects of feeding 1-1/2 pounds of cottonseed meal per head per day vs. 1-1/2 pounds of sorghum grain per head per day on the gains of yearling steers during the low quality forage period of native summer range.

Pastures are stocked from May 1 to October 1 at a moderate rate of 3.60 acres per head with yearling steers. From August 1 to October 1, the steers in one lot receive cottonseed meal at the rate of 1-1/2 pounds per head per day and those in the other lot are fed sorghum grain at the same rate. The supplementation treatments are alternated between pastures each year. The steers are weighed monthly following a 12-hour shrinkage. The major forage species are sampled at average grazing heights monthly for crude protein analyses.

Progress: Kansas Agricultural Experiment Station Bulletin 394 contains a summary of comparisons of cottonseed meal vs. no supplementation on moderately grazed pasture from 1949 to 1957. Average steer gains during that period were 46 pounds per head greater in the supplemented pasture. Results of the comparisons between cottonseed meal and sorghum grain as supplements are inconclusive. During three of four years, a sorghum grain supplement produced gains equal to or slightly superior to cottonseed meal supplement. Cottonseed meal resulted in the better gains during one year. There has been no clear-cut relationship between protein content of the forage and a response to added protein.

Title: COMPARISON OF TWO RATES OF GRAZING ON LOWLAND RESEEDED WESTERN WHEATGRASS

Leaders: J. L. Launchbaugh and J. R. Brethour

Objectives: To compare (1) gains per head, (2) beef production per acre, (3) length of grazing season, and (4) effects on vegetation on old stand of lowland reseeded western wheatgrass grazed at two intensities.

Pastures established in 1948 and moderately grazed until 1957, have been grazed at two rates (1.25 and 2.50 acres per head) the past three years. The pastures are stocked with yearling steers in April and removed after the vegetation has been fully utilized. Steer gains and vegetation studies are handled by the procedures outlined in project: Hays 254-A.

Progress: Kansas Agricultural Experiment Station Bulletin 400 summarized results of grazing western wheatgrass in comparison with other species from 1948 to 1957. The following table shows averages of major results from these trials:

Pasture	Buffalograss	Western Wheatgrass	Intermediate Wheatgrass
Carrying capacity, A/hd.	2.3	2.0	1.9
Grazing period, days/yr.	145	157	150
Steer gains, lbs./hd	161	192	213
Gains per acre, lbs.	69	100	112

The intermediate wheatgrass died out as a result of drought during the early 1950's and was abandoned. The buffalograss was subjected to heavy silting during a flood in 1957 and was removed from the test leaving the western wheatgrass for an intensity of grazing study. Although results from this phase of the study are inconclusive, it appears that western wheatgrass may be grazed fairly heavily from late April to July 1 and still produce high individual and optimum per acre gains compared with a moderate stocking rate during the same period. So far, there have been no significant changes in the vegetative cover under the two stocking rates.

Title: COMPARISON OF UPLAND RESEEDED WESTERN WHEATGRASS, SWITCHGRASS, CAUCASIAN BLUESTEM, AND A WARM-SEASON NATIVE GRASS MIXTURE FOR GRAZING STEERS

Leaders: J. L. Launchbaugh and J. R. Brethour

Objectives: To compare the grazing values of various reseeded species on upland: (1) starting dates, (2) length of grazing season, (3) carrying capacity, (4) gains per head, (5) beef production per acre, and (6) longevity of grass stand when managed for full utilization. To determine the effects of grazing on yield, ground cover and botanical composition of the reseeded species.

The plantings were made in 1957 in a randomized block design with two replications on a uniform clay upland site. Grazing was started in 1958 on western wheatgrass and caucasian bluestem. Grazing commenced on the other pastures in 1959. Stocking procedure is to vary starting dates, steer numbers, and removal dates each year according to the productivity of each pasture in order to realize optimum gains without over-utilizing the forage. Late season supplementation with cottonseed meal fed at the rate of 1-1/2 pounds per head per day was started in 1959. Steer gains and vegetation studies are handled by the procedures outlined in project 254-A.

Progress: Although it is too early to draw conclusions, yearling steer performance during 1959 is shown in the following table:

Pasture	Western Wheatgrass	Caucasian Bluestem	Switchgrass	Native Mixture
Carrying capacity, A/hd	2.2	1.4	2.2	2.2
Days on pasture, number	168	107	149	107
Gain per head, pounds	138	161	221	179
Gain per acre, pounds	62	113	100	81
Forage production, lbs./A	4,510	5,010	4,700	3,720

Title: CULTURAL REQUIREMENTS OF GRASSES

Leader: Marvin L. Lundquist

Progress: The following species are being established for study of cultural requirements (including response to fertilizer and clipping) under sandyland conditions in south-central Kansas.

1. *Panicum virgatum* (Blackwell)
2. *Andropogon gerardi* (Kaw)
3. *Andropogon ischaemum* (El Kan)
4. *Andropogon intermedius*
5. *Andropogon scoparius* (KG 1580)
6. *Andropogon hallii* (Woodward)
7. *Eragrostis trichodes*
8. *Bouteloua curtipendula* (El Reno)
9. Warm-season grass mixture (SCS recommendation for area)

Title: EFFECT OF BURNING ON BLUESTEM PASTURES

Leaders: E. F. Smith, K. L. Anderson, B. A. Koch, F. W. Boren, and
B. D. Carmack, Departments of Animal Husbandry and Agronomy

Objectives: To compare non-burning of bluestem pastures with early, mid, and late spring burning.

Progress: Burning has reduced forage yields, especially under early spring burning. Steer performance has been improved under mid and late spring burning.

Burning naturally eliminates surface mulch. This allows water to escape, and yields of forage are reduced. All burned pastures yield less forage than unburned ones despite increased beef gains under the later burnings. There seems to be somewhat closer use on burned pastures. Early burning has resulted in severe reductions in the grasses that decrease under grazing.

Title: WINTERING AND GRAZING YEARLING STEERS

Leaders: E. F. Smith, F. W. Boren, B. A. Koch, and B. D. Carmack

Objectives: To determine the effect of winter plane of nutrition on future performance including carcass comparisons.

Progress: Animals wintered on pasture compared to drylot appear to produce lower grading carcasses.

Title: WINTERING AND GRAZING STEER CALVES

Leaders: E. F. Smith, F. W. Boren, B. A. Koch, and B. D. Carmack

Objectives: The objective of this project is to determine the nutrients necessary to improve performance on mature winter dry bluestem pasture and on late summer pasture.

Progress: Supplemental phosphorus is being tested at present and to date no response has been obtained from furnishing additional phosphorus to that found in the forage and normal supplemental feeds.

Title: WINTERING, GRAZING, AND FATTENING HEIFERS

Leaders: E. F. Smith, D. L. Good, F. W. Boren, B. A. Koch, and B. D. Carmack

Objectives: To improve early summer performance of animals on pasture that normally make very small gains due to previous winter treatment.

Progress: Current tests include a comparison of performance of animals wintered in drylot and on pasture, both groups fed the same ration (prairie hay and alfalfa hay). Gains to date indicate drylot wintering is more desirable as measured by winter gains.

Title: WINTERING, GRAZING, AND FATTENING STEER CALVES

Leaders: E. F. Smith, B. A. Koch, D. Richardson, and F. W. Boren

Objectives: To evaluate materials for increasing performance of steer calves.

Progress: Stilbestrol implants have increased steer gains on pasture; and aureomycin-salt mixture is to be tested.

Title: EVALUATION OF LEGUMES, NATIVE AND INTRODUCED, OTHER THAN ALFALFA

Leader: C. E. Wassom

Progress: Over 500 accessions have been sown in nurseries, both on dryland and under irrigation. Tests with grasses have been planted but it is too early for definite conclusions or recommendations to be made.

MONTANA

Title: PALATABILITY OF SEVENTEEN GRASSES WHEN GRAZED AT THREE STAGES OF GROWTH

Leader: Arthur L. Dubbs

Objectives: To determine the palatability of 17 grasses on dryland when grazed by sheep and heifer calves at approximately the vegetative, heading and mature stages of growth. Three sheep were used in 1957 and 1958 and two heifers in 1959. The animals were allowed free choice of the grasses at each stage of growth. At weekly intervals an estimate of the percent consumed was determined.

Progress: The most palatable grasses at any stage of growth to both sheep and heifers were Russian wildrye, orchard, timothy, red fescue and smooth brome. Only Russian wildrye is adapted to dryland conditions at Moccasin. The wheatgrasses in general were not preferred as they advanced in maturity past the heading stage. In general, the sheep preferred the shorter grasses or those species which were leafy while the heifers were not quite as choosy and would eat some of the taller grasses. Beardless wheatgrass was the least preferred of the 17 grasses to both classes of animals. One half of each grass plot was fertilized with nitrogen in the fall of 1959 and will be grazed by sheep in 1960.

Title: STANDARD CRESTED WHEATGRASS AND NATIVE SOD RENOVATION

Leader: Arthur L. Dubbs

Objectives: To fertilize and add legumes to an old established stand of standard crested, and to native sod consisting mainly of blue grama. The legumes consisted of Ladak alfalfa and sickle milkvetch and the fertilizer 11-48-0, 0-43-0, and 33-0-0 applied at the rate of 100 lbs. per acre. The fertilizers were applied with and without each legume in a split plot design replicated 6 times. An International Pasture Renovator was used to apply the fertilizers and legume seed.

Progress: No stands of alfalfa or sickle milkvetch were established in the native sod. Plots receiving nitrogen alone or with phosphate showed a response, however, the growth was short and yields were not taken. Phosphate alone showed no response. In the crested, alfalfa was established on all plots except those receiving 33-0-0. Sickle milkvetch did not become established on any plots. Those plots receiving phosphate alone contained the highest percentage of alfalfa after four years with 69%, while plots treated with 11-48-0 contained 35% alfalfa and no added fertilizer 52%. Results seem to indicate that one of the best methods of renovating crested wheatgrass is to add an adapted legume.

Title: MORPHOLOGICAL DEVELOPMENT OF RANGE GRASSES AND THE EFFECT OF SIMULATED GRAZING ON GRASS MORPHOLOGY

Leader: Gene F. Payne

Objectives: To determine the effect of various rates and dates of foliage removable on the production of range grasses.

Progress: Total foliage removal on June 25 for four years has resulted in almost complete destruction of the productive capacity of A. spicatum, and has severely reduced the productive capacity of S. comata. The numbers of culms per live plant have also been greatly reduced. Leaf lengths have varied more among treatments than among years at the June 25 clipping date. The ground level clippings of June 1, May 1, and July 5 were progressively less damaging in terms of harvested production, but in all cases production has decreased. Production of bluebunch wheatgrass plants clipped to ground level in October has increased slightly, while plants clipped to ground level between November 15 and December 1 have increased in production. Needle-and-thread plants clipped on the October and the November dates show no discernible trend in foliage production. Clipping at 50% of foliage production on June 25 has caused decline of production. Clipping at 25% of foliage production on June 25 has not reduced productive capacity.

Title: UTILIZATION OF GRAZING LAND BY RANGE SHEEP TO PREVENT DETERIORATION AND BUILD UP CARRYING CAPACITY

Leader: Gene F. Payne

Objectives: To compare the effect of pocket gopher and sheep grazing activities on vegetation of high mountain dry meadows.

Progress: This project was started in 1943. Vegetation has been analyzed periodically since that time. Gopher activity has detrimentally affected Idaho fescue, California oatgrass, Timber oatgrass, Prairie wedgescale, Subapline needle grass, Western yarrow, and common dandelion. Slender wheatgrass increased where gophers were active. Sheep grazing caused decreases of mountain brome, northern bedstraw, cinquefoil and increases of Timothy, Kentucky bluegrass and Bellflower. Snow depth and water content studies during the last two years have shown that the fences have not significantly affected amounts of snow moisture in the plots. There are significant differences among major plot locations.

Title: RANGE FORAGE PRODUCTION CHANGES THROUGH WATER-SPREADING PRACTICES

Leader: D. E. Ryerson. Cooperating with Bureau of Land Management and Geological Survey, Department of Interior

Objectives: To determine the effect of water-spreading on soils, vegetational composition, forage production, and methods of revegetating denuded areas by mechanical measures.

Progress: A water-spreader system has been established on severely denuded soils. Changes will be measured in forage production by species, basal cover and percent composition. A species adaptation study coupled with techniques for their establishment are also incorporated into the study. Water-spreading occurred in the spring of 1959 on the area and substantially increased the total forage produced. The increase was primarily Nuttall saltbush (Atriplex nuttallii) and annual forbs. Cover as a result of water-spreading was nearly doubled in the first year. Reseeding with all species resulted in poor stands or failures. Preliminary soil analysis indicate that acid conditions are prevalent throughout the area and that a high sodium content is causing puddling of the soil surface. The soils in the area are classed as clays and clay loams with poor structure. There was insufficient western wheatgrass (Agropyron smithii) for natural revegetation by this species to occur.

Title: RANGE IMPROVEMENT THROUGH THE USE OF RENOVATION PRACTICES FOR UNDESIRABLE RANGE PLANT CONTROL

Leaders: D. E. Ryerson and F. B. Gomm

Objectives: 1. To determine effective and practicable methods for the control of undesirable range plants.

2. To determine the effects of physiographic, climatic and range conditions upon the success of the methods used.

3. To determine the effect upon vegetational composition, forage production and soil water stabilization on a long term basis.

Progress: Chemical studies on big sagebrush indicate that effective controls of this species can be obtained with use of 2,4-D; 2,4,5-T, or a mixture of 2,4-D plus 2,4,5-T at rates of one pound per acre under the conditions of the study when water was used as a carrier. Oil as a carrier in this study did not appear as effective as water when applied as a ground spray. Forage production three years after treatment has shown an average net increase of 125 percent for all chemical rates and carriers. Burning gave excellent control of big sagebrush but had a detrimental effect on forage production the first year after treatment. It has required three years for grass yield to increase materially. Neither burning nor chemicals used in this study gave control of rabbitbrush (Chrysothamnus sp.).

Title: EFFECT OF MECHANICAL RENOVATION PRACTICES, FERTILIZATION AND SEEDING ON RANGELANDS OF NORTHERN MONTANA AS MEASURED BY VEGETATIONAL AND SOIL CHANGES

Leaders: D. E. Ryerson, John Reuss, and F. B. Gomm, ARS; H. A. R. Houlton, North Montana Branch Station, Havre, Montana. Cooperating with Bureau of Land Management.

Objectives: To determine the effect of mechanical treatments, fertilization, and reseeding on range condition improvement, soil relationships, forage production, vegetational composition and grazing relationships on deteriorated rangelands.

Progress: Small plot studies were established in 1958 and 1959. Havre: Untreated native range produced ca. 500 lbs./A, made up of Stipa comata, Bouteloua gracilis and Agropyron smithii. Forage production was significantly reduced by pitting, the first growing season after pitting. Applications of nitrogen from 0 to 100 lbs./A on non-pitted range showed a beneficial increase in forage production over non-fertilized range. Fertilization at 150 lbs./A had a depressing effect on production. Total production on an area pitted five years previously was significantly higher than on adjacent non-pitted

range. Crested wheatgrass, Russian wildrye and sweetclover seeded at time of pitting was a failure. Glasgow: Preliminary soil tests showed eroded surface soils with a pH of 6.9 or less. At 18 inches the average pH was 4.8. This is in a low rainfall area. The eroded soils had an electro-conductivity greater than four and a high sodium content.

Title: EVALUATION OF EXISTING, AND DEVELOPMENT OF NEW, RANGE MEASUREMENT TECHNIQUES

Leader: George M. Van Dyne

Objectives: 1. To evaluate existing methods and combination of methods of measuring seasonal and total range forage production, utilization, basal area, and range condition.

2. To develop new techniques of range measurements.

Progress: Studies have been made in the past year evaluating methods of measuring forage production, methods of basal cover analysis, and inter-relationship of weight and coverage measurements. A capacitance meter, electrical clippervacuum pickup device, and size and shape of plot studies were evaluated for production measurements. Point analysis, 3/4" loop measurements and weight measurements were evaluated in relation to their estimates of composition of range vegetation. Special equipment was constructed for installing and reading line intercept transects.

Title: PALATABILITY, PRODUCTIVITY, AND CHEMICAL AND BOTANICAL COMPOSITION IN RANGE FORAGES AS INFLUENCED BY FERTILIZATION

Leaders: George M. Van Dyne, Harry Kittams, and Don E. Ryerson

Objectives: 1. To study the effects of fertilization on the palatability of range forages.

2. To determine changes in production of dry matter and nutrients of range forages influenced by fertilization.

3. To evaluate changes in botanical composition of ranges influenced by fertilization.

Progress: A study was initiated in the spring of 1959 to evaluate influence of fertilization of native rangeland on the forage production, basal coverage, palatability of forage and changes in chemical composition. Nitrogen and phosphorus were applied to selected plots in a factorial design in three replications on the Red Bluff Ranch. Measurements of forage production were made by species and total weight, utilization was measured, and basal coverage was measured by line intercept transects. Increases in production

were found due to the nitrogen fertilization which also influenced the nitrogen content of the forage.

Basal cover was not modified for most variables by fertilization. Palatability of forages was not influenced in the late summer grazing period, but during the winter considerable preference was expressed by the livestock for the plots receiving the high levels of nitrogen.

Title: NUTRIENT PRODUCTION OF RANGE PLANTS ON PLAINS, FOOTHILL, AND MOUNTAIN AREAS OF MONTANA

Leaders: George M. Van Dyne and Harry Kittams

Objectives: 1. To determine the influence of site and climate on the nutritive content of native vegetation.

2. To determine the variation in nutrients between the stems, leaves, and heads of important range plants.

3. To study the seasonal trend in nutrients of range plants.

Progress: Forage samples were obtained from exclosures on the Red Bluff Ranch at approximately 75 locations during the summer of 1959. Soil samples from the major rooting zone were obtained from each exclosure area as well as information concerning the slope per cent, exposure soil depth, and other site data. Forage samples have been composited for chemical analyses.

These factors are to be evaluated statistically with the following dependent and independent variables:

Dependent

Weight of individual species
Weight of species groups
Total weight produced
Per cent protein in forage
Per cent phosphorus in forage
Per cent lignin in forage
Pounds protein per acre
Pounds phosphorus per acre
Pounds lignin per acre

Independent

Per cent slope
Degrees of exposure
Soil depth
Relative moisture
Elevation in feet
Soil texture
Conductivity
Soil ph
Soil organic matter
Soil phosphorus

Title: EVALUATION OF THE QUANTITY AND QUALITY OF THE DIET OF RANGE SHEEP

Leaders: George M. Van Dyne and J. L. Van Horn

Objectives: 1. To study the effects of range type, climate, type of supplement, and management in the foraging performance of range sheep.

2. To study the digestibility of range forage complexes.

3. To develop new techniques and compare existing techniques for measuring the quantity and quality of the diet of sheep grazing on Montana ranges.

Progress: Several ewes were equipped with esophageal fistulas with lucite cannulas. From four to eight ewes were used in obtaining forage samples of grazed forage of freely grazing sheep. Forage collections were made morning and evening every other day throughout the three month winter grazing period. An additional eight ewes were selected from two other seed treatment groups in a range band of experimental sheep and were used for fecal and urine studies. These ewes were equipped with appropriate apparatus to collect quantitatively the feces and urine during selected sampling periods. Two periods of seven days each (preceded by a seven day preliminary period) were studied. Forage and fecal samples are now being analyzed chemically. This information will be used to study the digestible and metabolizable nutrients in the forage.

The route of travel of the band of sheep was plotted on large scale aerial photographs to relate changes in grazing to climatic conditions and forage intake. The distance travelled was measured on three wethers with the use of a "range meter."

Title: FEED MANAGEMENT OF EWES ON A FOOTHILL RANGE

Leaders: J. L. Van Horn, O. O. Thomas, J. Drummond, A. S. Hoversland, G. M. Van Dyne, and F. S. Willson

Objectives: 1. To accumulate performance data for a period of years from ewes wintered on a foothill range with and without supplemental feed.

2. To investigate wintering regimes for ewes wintered on foothill range (range phase involves wintering a group of ewes by a supplemental procedure based on a range index).

Progress: Range Phases. An estimate of the available forage in pounds per acre and pounds of nutrients per acre was made at each sheep camp area which was grazed during the winter period. Prior to grazing each of the four to five winter camp areas was sampled by a large number of plots located by stratified randomization. Forage composition within each of these plots was estimated to the nearest 5 or 10 per cent by weight. The material was then clipped for total weight determinations. The major forage species occurring in each winter camp area was clipped by hand and prepared for chemical determinations. The total feed available, the protein content of the forage, the relative composition of the forage, and weather conditions were evaluated subjectively in determining the level and kind of supplement to be fed. A group of 80 ewes were supplemented by this index.

NEBRASKA

Title: OUTSTATE TESTING - FERTILIZER EXPERIMENTS ON NATIVE GRASSLAND

Leaders: E. M. Brouse and H. F. Rhoades

Objectives: 1. To determine the effect of various combinations of commercial fertilizers on the yield, chemical composition of forage, and the botanical composition of sandhill meadows.

2. To determine the fertilizer practices necessary for maximum economy of forage production.

Progress: A new experiment was conducted with two rates of potassium fertilizer applied with four rates of nitrogen fertilizer at eight locations with varying levels of available potassium in the soil. Additional experiments are needed to obtain a satisfactory correlation between available potassium levels in the soil and the response of wet meadow vegetation to potassium fertilizer.

Over a three- to five-year period, the annual application of nitrogen on four meadows which had received an initial application of phosphate did not cause a profitable increase above that received from the phosphate application alone. There was no significant difference in yield due to time of applying the nitrogen. The June application was least and fall application most effective in stimulating bluegrass.

Mean yields of the third year's crop indicates only small differences due to rate or frequency of applying phosphorus fertilizer at four sites. Over a six-year period residual response has been obtained on 50 to 75 percent of the meadows fertilized with phosphorus.

The protein content of the 1957 hay crop was reduced by the application of nitrogen, except where high rates were used. Phosphorus fertilizer caused an increase in protein at all but one site. All applications of phosphorus fertilizer caused an increase in the phosphorus content of the hay. The residual influence may be effective for several years.

Title: THE INFLUENCE OF DIFFERENT LEVELS OF STOCKING ON SUMMER LIVESTOCK GAINS AND THE CONSEQUENT CHANGES IN BOTANICAL COMPOSITION, RANGE CONDITION, AND QUALITY OF FORAGE ON WESTERN NEBRASKA RANGELAND

Leaders: D. F. Burzlaff, J. K. Matsushima, and L. C. Harris

Objectives: 1. To determine the effect of three levels of stocking on summer gains of livestock on Nebraska rangeland.

2. To determine the influence of varying degrees of utilization on condition and botanical composition of rangeland.

3. To determine seasonal trends in nutritive content of major forage producing species.

Progress: The 1959 data resulted from the second year of grazing. The treatment has not been in effect long enough to create trends in summer gain as a result of the differential stocking.

Seasonal trends in gain have been carefully watched. This will be correlated with data collected relative to seasonal trend in protein content of forages.

Title: FACTORS AFFECTING THE CLASSIFICATION OF RANGE SITES IN NEBRASKA SANDHILLS

Leaders: D. F. Burzlaff, H. F. Rhoades and A. P. Mazurak

Objectives: 1. To classify the range sites of the sandhills on the basis of edaphic and vegetation characteristics.

2. Determine the edaphic factor or factors that are associated most closely with the distribution of grasses within the sandhills.

Progress: Field work and analysis of data relative to three range sites have been completed. The data are being summarized and formulated into form for publication.

Calamovilfa longifolia is the most important grass on the Dry Valley, Rolling Sands and Choppy Sandhill range sites.

Correlations of the percent of particles in the silt-clay fraction and the organic matter content of the soil with the moisture retention ability in the available range and with the cation-exchange capacity indicated these characteristics to be highly interdependent variables.

Texture, cation-exchange capacity, percent organic matter and the percent of moisture retained between 1/10 and 15 atmospheres of tension were considered

to be the units of the soil factor that were most influential in controlling the distribution of vegetation in the sandhills in Nebraska.

It was theorized that those species exhibiting a narrow range of tolerance to minor changes in the soil factor were of more value as indicators of a specific soil condition than those species with a broad tolerance range for changes in the same factor.

Title: EFFECT OF VARYING ENERGY AND PROTEIN LEVELS DURING THE WINTER ON PRODUCTIVITY OF BEEF COWS

Leaders: D. C. Clanton, J. K. Matsushima, and D. R. Zimmerman

Objectives: 1. Evaluate how varying energy and protein levels in beef cow rations during the winter affect maintenance of body weight, fertility, and production.

2. Compare TDN, digestible energy and metabolized energy values of rations containing different levels and combinations of protein and energy.

Progress: Project initiated in 1959.

Title: CATTLE MANAGEMENT PRACTICES IN THE RANGE AREAS OF NEBRASKA

Leaders: D. C. Clanton, J. K. Matsushima, R. M. Koch, D. F. Burzlaff, R. L. Sweat, L. C. Payne, J. E. Ingalls, W. W. Rowden, and K. E. Gregory

Objectives: 1. Evaluate feeding and management practices for calves at weaning time and during the winter.

2. Evaluate summer and winter management systems to optimize sustained production from beef cows and steers.

3. Evaluate the use of growth promoting products for calves and yearlings on pasture.

Progress: Project initiated in 1959.

Title: EFFECTS OF FERTILIZATION PRACTICES ON THE YIELD AND CHEMICAL COMPOSITION OF UPLAND PRAIRIE HAY

Leader: E. C. Conard

Objectives: 1. To determine the effects of various fertilizer elements alone and in combinations on the yield and chemical composition of upland prairie hay.

2. To study the effects of fertilization practices on the botanical composition of the meadow vegetation.

Progress: Plots which had received the high rates of nitrogen and phosphate fertilizers, either alone or in combination, produced greater yields of hay than the unfertilized plots. Statistically, the differences in yield are highly significant; but in general, they would be of minor economic importance to the farmer or rancher. The greatest increase in yield over the check plots was 0.42 of a ton per acre. This occurred on the plots which received 120 pounds of P_2O_5 per acre in 1953 and 120 pounds of N per acre each year, 1953-1955.

There have been no measurable effects on yield from the application of potassium nor lime in combination with the other fertilizers.

Title: DEVELOPMENT AND UTILIZATION OF IMPROVED PASTURE TECHNIQUES FOR THE EVALUATION OF FORAGE GRASSES

Leaders: E. C. Conard, Dale Wolf, L. C. Newell, J. Matsushima,
D. C. Clanton and V. H. Arthaud

Objectives: 1. To determine the relationships between productivity and palatability of different grasses as measured by animal performance and forage production (from caged areas of the pasture).

2. To develop a method of harvesting small plots which will simulate varied intensities of grazing.

Progress: Twelve pastures were grazed with yearling steers. Grazing started May 3 on the cool-season pastures and June 11 on the warm-season pastures. The cage method, with ten cages per pasture was used to estimate herbage production and consumption. The total digestible nutrients consumed were estimated from animal performance. These two methods are being compared to determine if clipping procedures can be used to estimate the results expected from animals.

The clipping study in exclosures in the pastures was continued for the second season in 1958. Clipping at a uniform 5-inch height at both 14- and 28-day intervals resulted in a marked decrease in the yields of four of the six grasses. There appears to be little difference in the effects under the uniform 5-inch height of clipping treatments. Several interesting trends can be noted among the treatments when the second and first year results are compared. However the study will have to be continued for at least another season to determine whether real differences develop. It appears that significant species--treatment interactions may be developing.

Title: THE EFFECT OF HORMONE IMPLANTS IN BEEF PRODUCTION ON WINTER AND SUMMER PASTURE

Leaders: J. Matsushima and L. C. Harris

Objectives: 1. To determine the value of hormone implant on winter gains of weaning steer calves.

2. To determine the carry-over effect of hormone implants (implanted at the beginning of the winter pasture season) through the subsequent summer grazing season.

3. To compare the value of a single implant at the beginning of the summer pasture season with implants made at two separate intervals--one at the beginning of winter pasture and re-implanted with the same hormone at the beginning of the summer pasture period.

4. To compare gains of the steers which received implants and those that did not receive implants.

Progress: Results of this study indicated that a fall implant of Synovex X caused calves to gain 18.2 percent more than the control animals.

Steers implanted for the first time at the beginning of the summer grazing phase gained 8.1 percent more than steers which received no implant at the beginning of either the winter or summer phase. Implanting at the beginning of the winter phase and no implant at the beginning of the summer period resulted in lowest gains.

Calves implanted at the beginning of both winter and summer phases did not increase gains over controls or over the steers implanted for the first time at the beginning of the summer phase.

No side effects such as high tail heads, depression of loin, or coarseness were noted in any of the cattle during the two periods.

Title: IMPROVEMENT OF FORAGE GRASSES AND OF GRASSLANDS

Leaders: L. C. Newell, Agricultural Research Service
and E. C. Conard

Objectives: 1. To increase the productivity, nutritive qualities, vigor and longevity of forage grasses through selection and breeding.

2. To evaluate, through nursery and field trials, the many species and strains of grasses for forage qualities, productivity, and adaptation to the different soil and climatic conditions in Nebraska.

3. To develop better methods of producing, harvesting and processing grass seeds, especially seed of the important native grasses.

4. To determine the best cultural practices in the establishment of grasses and legumes for pasture, meadow, conservation, and turf plantings.

Progress: Nurseries of spaced plants of both cool- and warm-season perennial grasses were evaluated for selection of superior clones for breeding purposes. These nurseries included domestic collections of switchgrass, big bluestem, sand bluestem, little bluestem, Indiangrass, sideoats grama, blue grama, sand lovegrass, intermediate wheatgrass, tall wheatgrass, and smooth brome grass.

Progenies of 100 selected clones of switchgrass were evaluated in second-year growth for seven characters, including forage and seed yields and quality, height of leaves and stems, and rust resistance. Plot tests of synthetic brome grass varieties were planted.

Data from progeny evaluations of selected clones of grasses are used in testing predictions of heritability made by different methods. Superior clones for specific characters are to be utilized in the production of new and superior varieties for forage and seed production and for special purposes.

New variety releases from the Nebraska Station include Holt Indiangrass and the joint release of Vinall Russian wildrye.

Title: THE INTRODUCTION, MULTIPLICATION, PRESERVATION, AND DETERMINATION OF POTENTIAL VALUE OF NEW ACCESSIONS AND STRAINS OF NATIVE AND EXOTIC GRASSES

Leaders: L. C. Newell, Agricultural Research Service and E. C. Conard

Objectives: To collect, grow, maintain, and find a preliminary evaluation of strains of native grasses and introductions from arid regions of the Old World in order to determine which offer the best possibilities for use by the plant breeders in developing strains that can be produced under certification on farms.

Progress: Maintained in nurseries are clonal materials and selected lines of crested wheatgrass, intermediate wheatgrass, tall wheatgrass, and brome grass from recent introductions; and switchgrass, bluestems, grama grasses, and lovegrass from 1949-1957 domestic collections. A two-year study of randomly selected endemic strains of switchgrass has furnished information on heritabilities of seven agronomic characters and indicated values of different sources of collection. A comparison of bluestem and switchgrass types, under different clipping management at three Nebraska locations, has furnished advance information on the adaptation of potential varieties to be developed from these materials.

Title: CHEMICAL, MORPHOLOGICAL AND NUTRITIONAL CHANGES OCCURRING IN GREAT PLAINS GRASSES AND THEIR RELATIONSHIP TO MANAGEMENT PRACTICES

Leaders: G. Van Riper and D. F. Burzlaff

Objectives: The purpose of the initial phase of this project is to investigate the carbohydrate food reserves (both qualitatively and quantitatively) of sand reedgrass (Calamovilfa longifolia), little bluestem (Andropogon scoparius), sand bluestem (Andropogon hallii) and switchgrass (Panicum virgatum) in relation to stages of growth and morphological development.

Progress: Project initiated July 1, 1959.

NEVADA

Title: IMPROVEMENT AND MANAGEMENT OF THE COMMUNITY PASTURES OF THE PERSHING COUNTY WATER CONSERVATION DISTRICT NEAR BATTLE MOUNTAIN, NEVADA

Leaders: J. H. Robertson, Howard P. Cords, Robert Ferraro, T. Joseph Snyder, George Mosely, Departments of Agronomy and Range Management. Cooperating with Pershing Co. Water Conservation District; Bureau of Reclamation, Department of Interior; and Nevada Extension Service

Objectives: 1. To determine trends in pasture condition and their causes under use and declining soil moisture.

2. To find patterns of use most favorable for sustained high forage production and weed suppression.

3. To learn how to establish pasture species better adapted to use than the natives.

Progress: Old Humboldt river-bottom hay meadows have been pastured, May - October, since 1951. The tendency of the river to flooding has been reduced by engineering works so that the habitat is gradually becoming more xeric.

Frequent mowing and clipping of Elymus triticoides have been followed by a greater decline in yield and increase in weeds than have delayed harvest. Heavily grazed pastures have become weedy, particularly with Iva axillaris. Applied nitrogen stimulated Iva much more under frequent clipping of Elymus. Better pasture grasses, including E. junceus, and Agropyron amurense could be established only with irrigation.

Isolation transect exclosures have been installed to study different grazing patterns.

Title: INCREASED STREAMFLOW AND FORAGE PRODUCTION THROUGH ERADICATION OF UNDESIRABLE VEGETATION, SEEDING AND GRAZING MANAGEMENT

Leaders: J. H. Robertson, H. P. Cords, Agronomy and Range Management, C. R. Torell, Animal Husbandry. Cooperating with Agricultural Economics, Soil and Water Conservation Branch, ARS; Bureau of Land Management, Nevada Research Center, IS and RES, Salmon River Cattle Association and State Fish and Game Department, Soil Conservation Service

Objectives: To explore the feasibility of using herbicides and fire in combination to clear brush for (a) increased flow of irrigation water, (b) increased forage, and (c) easier handling of stock. Big sagebrush is the species of primary interest.

Progress: Transpiration, root habit, water table and brush control studies are underway.

Preliminary transpiration tests show that sagebrush wastes soil moisture. In some places it influences spring and stream flow. Its roots enter the zone of capillarity but stop short of the water table.

Water tables of 6 to 10 feet appear favorable for big sagebrush to attain heights of 6 to 8 feet. Flow characteristics of 2 creeks are being studied. Evapo-transpiration losses were highest in July, being as high as 42% of the flow along a one-mile segment of the stream bordered by sagebrush, roses, and a few common phreatophytes.

Future Plans: Stream calibration will continue, brush sprayed last May will be burned this April, as a fireline for July burning, and October seeding. Effects on watertable will be observed.

The reader may refer also to Nevada Circulars 22, 1958 and 25, 1959, progress reports, Range Management Research.

NEW MEXICO

Title: ECONOMIC APPRAISAL OF DROUGHT AND DROUGHT-RECOVERY PRACTICES
ON RANCHES IN NEW MEXICO

Leaders: Calvin Boykin, Agricultural Research Service.
Cooperating with James R. Gray.

Objectives: 1. Determine changes New Mexico plains ranchers made in organizing and operating their ranches in drought and drought recovery periods.

2. To measure the effects of these changes in terms of net incomes and net worths.

3. To develop methods of measuring risks.

4. To develop the basis for recommendation for management practices to cushion the impact of drought on ranches in New Mexico.

Progress: Case histories of sixteen ranchers were developed to include the usual management practices and major decisions made going into and coming out of drought conditions. These data extend back to 1959 and detailed case data have been taken for the 1957, 1958, and 1959 period.

Of the sixteen cases under study, livestock numbers were reduced only moderately during drought periods. Most reductions involved closer culling and the sale of old breeding stock at earlier ages. Feeding increased as range forage became scarce to the extent that in some drought years, feeding was carried on yearlong. Most ranchers tried to maintain adequate breeding herds since livestock prices were low during the drought. Calf and lamb crop percentages decreased slightly. Time of calving and lambing was spread over a longer period. Costs were reduced during drought by delaying range improvements, deferring large capital investments, and reducing the amounts of hired labor used.

Future Plans: These will consist of analysis of the data already collected, to include budgeting alternative practices and measuring the effects of various strategies chosen, and collection of additional data on changes in range productivity during the study period. Additional secondary data may be collected from various public and state land agencies.

Title: INFLUENCE OF GRAZING USE ON RECOVERY OF DROUGHT DAMAGED DESERT GRASSLAND RANGE

Leaders: J. J. Norris and K. A. Valentine

Objectives: To determine the influence of grazing on recovery of drought damaged black grama rangeland. Underlying this is the broader objective of determining whether use appreciably lighter than that considered proper for range in good condition is essential in order to promote a satisfactory rate of recovery of range which has been severely depleted by drought. Four levels of use are being applied by natural grazing at three locations. The project was started with grazing of the 1954 forage crop. Grazing of the 1956 crop was suspended because of drought.

Progress: To-date, height growth and reproduction response has been consistently better for the light and moderate use treatments than for the so-called proper use and heavy use treatments. Effects of treatments have not yet been evaluated in terms of stand and yield of the major forage species.

Title: ARTIFICIAL REVEGETATION OF DESERT GRASSLAND RANGE IN NEW MEXICO

Leaders: J. J. Norris and K. A. Valentine

Objectives: To determine the following points with respect to reseeding on desert grassland range.

1. Adapted species and varieties.
2. Sites suitable for reseeding.
3. Methods of planting.
4. Grazing values of adapted species.
5. Factors affecting reproduction of adapted species.

Progress: Among exotic species tested, Lehmann lovegrass has given best results. Yields of forage of 450 pounds per acre have been obtained under good rainfall conditions. Rodent and rabbit influences are commonly very adverse to successful seeding and on some brushy sites they alone prevent success. Although Lehmann lovegrass is relatively unpalatable to cattle, they can be made to use it. Gains of 0.71 pound per day on the mature grass have been obtained. Owing to climatic limitations, reseeding is a risky undertaking on desert grassland range. Numerous trial plantings have indicated that less than 50 percent success is to be expected. No species tried is the equal of the native black grama in stand stability, a most important criterion of success on desert grassland ranges subject to severe wind erosion.

Title: FORAGE PRODUCTION AND APPRAISAL

Leaders: K. A. Valentine and J. J. Norris

Objectives: To determine variation in annual forage production on desert grassland range and to develop methods of forage crop appraisal. Observations of rainfall, stand and yield of principal forage species and personal estimates of stand, average plant growth and yield are being made. Data for seven years at four locations has been obtained.

Progress: Owing to wide variation in stand from place to place and year to year, forage production has shown poor correlation with rainfall. When stand is considered in conjunction with rainfall, correlation is highly significant. Personal estimate methods of forage crop appraisal have shown considerable variation between methods and between estimators; however almost all have been sufficiently accurate to serve as a basis for needed stocking adjustments under short forage conditions.

Title: CONTROL OF MESQUITE ON DESERT PLAINS GRASSLAND RANGE

Leaders: K. A. Valentine and J. J. Norris

Objectives: 1. To determine the value of various hormone type herbicides in control of mesquite.

2. To determine the value of substituted urea herbicides in control of mesquite.

3. To determine the cost and effectiveness of foliage spraying mesquite with 2,4,5-T, using ground application equipment on a field scale basis.

Progress: Of the hormone type herbicides, 2,4,5-T in the propylene glycol butyl ether esters formulation has generally given the best or among the best results; however in years of exceptionally good fall-spring precipitation propionic acid and pentyl ester formulations have given results comparing favorably with the P.G.B.E. esters. Of the substituted ureas, monuron has shown superiority over fenuron and diuron has been very ineffective. Costs (including equipment, material and labor) of field scale spraying of 2,4,5-T have ranged from \$0.54 per acre for 10-plant-per-acre infestations to \$1.65 per acre for 154-plant-per-acre infestations. Kills (complete kill) have varied from 36 to 75 percent. Correlation of kill with fall-spring precipitation prior to spraying in late May or early June is highly significant.

Title: RELATION OF INSECTS TO SEED PRODUCTION AND REESTABLISHMENT
 OF RANGE GRASSES

Leader: J. G. Watts

Objectives: 1. To determine the extent to which stand and yield factors of range grasses are affected by the harvester ants (Pogonomyrmex spp., Veromessor spp.) and other ants.

2. To determine the influence of insects on seed set of black grama grass.

Progress: The insecticides aldrin, dieldrin, heptachlor and S. D. 4402 have proved effective in controlling harvester and populations when applied to alfalfa seed and cracked wheat baits in rations of one part insecticide to 400 parts of bait. Other insecticides have proved less effective or ineffective in this respect

An experiment designed to study the effects of harvester ant control with insecticide treated seed baits on the reestablishment of large tracts of rangeland was also initiated. Various treated baits were applied to a 40-acre plot of rangeland immediately after reseeding with 4 species of grass seed. No results have been obtained to date.

Of the insects and related arthropods found on black grama, leaf hoppers, plant bugs, thrips and spider mites fall in the suspect category. Although none of these have been definitely linked with the problem of poor seed set, an erratic increase in mature seed following insecticide applications suggests the possibility that one or more of them may be involved.

Title: RODENT POPULATIONS OF THE DESERT GRASSLAND RANGE AND FACTORS
 AFFECTING THEIR NUMBERS

Leader: J. E. Wood

Objectives: 1. Determine the distribution and relative density of rodents on range lands in various stages of succession.

2. Determine the rate of population increase of rodents on range land under different inter-and intra-specific population pressures.

3. Evaluate the effects on range vegetation of rodent populations at various densities along the population curve.

4. Determine the effects of habitat management (mainly brush control) on the population density of rodents.

5. Determine the rate of rodent repopulation by immigration and reproduction on varying size areas after the populations have been reduced by control measures.

Progress: This study is just getting underway. Cover types for study have been selected and initial surveys of flora and fauna are in progress.

NORTH DAKOTA

Title: BOTANICAL COMPOSITION AND FORAGE PRODUCTION OF NATIVE GRASS GRAZING LANDS IN WESTERN NORTH DAKOTA

Leaders: Warren C. Whitman, Department of Botany, M. L. Buchanan and D. W. Bolin, Department of Animal Husbandry

Objectives: To determine the forage production and vegetative composition of native grass range types in western North Dakota in relation to their range condition status.

Procedures: At the present time 16 sample areas, averaging 3 to 5 acres in size, are under detailed study. On each sample area 10 movable steel cages are used to determine annual forage yield and species composition of the yield. Material in the cages is clipped at a height of 1 inch at the end of the growing season, and each cage is moved to a new location for the next year's yield clipping. Basal cover of vegetation on each of the study areas is determined every two years, using the point system of cover analysis.

Progress: Average forage production of the 16 types over the 9-year period of the study has been 1,044 lbs. per acre (oven-dry weight). The highest producing type has averaged 1,674 lbs. of dry material per acre, and the lowest producing type has averaged 750 lbs. per acre for the period. Western wheatgrass (Agropyron smithii) has produced the largest single portion of the yield on the types, 37.8 per cent of the total production. Needle-and-thread (Stipa comata) has produced on the average 15.0 per cent of the yield. West Western wheatgrass and needle-and-thread are the principal mid-grasses in the vegetation.

Blue grama grass (Bouteloua gracilis), the principal short grass, has produced 15.8 per cent of the yield. Two upland sedges, threadleaf sedge (Carex filifolia) and needle-leaf sedge (C. eleocharis), have produced an average of 6.0 and 4.5 per cent of the yield, respectively. Thus, five species--western wheatgrass, needle-and-thread, blue grama grass, and the two sedges--have produced 79.1 per cent of the yield, with all other grasses together producing only 13.6 per cent of the average yield. The forbs (broad-leaved plants) produced only 7.3 per cent of the yield.

The results of the cover analyses show that the mid-grasses, western wheatgrass and needle-and-thread, make up about 16 percent of the basal cover, but on the average they provide together 53 percent of the yield. Blue grama grass and the two sedges, considered together as short grasses, make up about 67 percent of the basal cover but provide only about 26 percent of the average yield.

Title: VALUE OF CRESTED WHEATGRASS AND CRESTED WHEATGRASS-ALFALFA PASTURES FOR SPRING GRAZING

Leaders: Warren C. Whitman, Department of Botany; R. J. Douglas, Larkin Langford, Dickinson Station; and M. L. Buchanan, Department of Animal Husbandry

Objectives: To determine the grazing capacity of crested wheatgrass and crested wheatgrass-alfalfa pastures when used as spring pasture for beef cattle.

Procedures: Two 8-acre pastures of crested wheatgrass and two 8-acre pastures of a crested wheatgrass-alfalfa mixture are used in the trial. The pastures are grazed in the spring and early summer by yearling steers. The period of grazing has averaged about 56 days during the 5 years of the trial (1955-59). The animals have begun grazing about the first of May on the average, with the grazing period terminating usually about June 25 to July 1.

Forage production and forage consumption on the pastures are determined by means of clippings inside and outside of movable steel cages, each 4' x 4'. Ten cages are used in each of the 8-acre pastures. Clippings from the crested-alfalfa pastures are separated into the grass and alfalfa components of the forage. All clippings are oven-dried and weighed. Crude protein is determined on composite samples.

The steers used in the trials have been yearling Herefords. Steers are weighed at the beginning of the trial, at the end of the first 28 days on the pastures, and at the termination of the grazing trial for the season.

Progress: For the 5 years of the trial the straight crested wheatgrass pastures have carried an average of 6 yearling steers on 8 acres during the spring grazing season, while the crested-alfalfa pastures have carried 8 steers on 8 acres. Forage production has averaged 940 lbs. per acre (oven-dry weight) on the crested wheatgrass pastures and 1,215 lbs. per acre on the crested wheatgrass-alfalfa pastures. Utilization has been uniform and heavy on both sets of pastures with an average removal of 80 percent of the forage produced.

The average seasonal gain per head on the crested wheatgrass pastures has been 112 lbs., the average daily gain per head 2.06 lbs., and the average gain per acre 86.2 lbs. Average seasonal gain per head on the crested-alfalfa pastures has been 118 lbs., average daily gain per head 2.16 lbs., and average gain per acre 118.2 lbs.

Over the 5-year period of the trial the crested-alfalfa pastures have produced 29.2 percent more forage than the straight crested wheatgrass pastures, have carried a 33 percent heavier grazing load, and have produced 37.1 percent more beef per acre. The alfalfa in the mixtures declined in productivity during the period of the trial, and while it initially provided about 48 percent of the forage, by the end of the fifth year it provided only 6 percent of the yield of the mixture pastures.

Both sets of pastures have provided excellent early season pasture. The crested-alfalfa pastures have been distinctly superior to the straight crested wheatgrass pastures. No trouble with bloat has been experience during the 5-year period of the trial.

Title: NATIVE RANGE PLANTS - THEIR GROWTH AND DEVELOPMENT IN RELATION TO THE ESTABLISHMENT OF STANDARDS FOR THEIR PROPER UTILIZATION

Leaders: Warren C. Whitman and E. A. Helgeson, Department of Botany

Objectives: To study the growth and development of important native range plants of western North Dakota and to evaluate their ability to survive and produce forage under varying degrees of defoliation; to select methods of determining range utilization that can be applied to western North Dakota ranges; and to establish standards for the proper utilization of the important range forage plants of the area.

Procedures: Study 1. This study involves a comparison of methods of determining utilization of native mixed grass ranges in western North Dakota. Three methods, the percent-of-plants-grazed, the ocular-estimate-by-plot, and the height-weight method were compared.

Progress: Study 1. It was found that the height-weight method was highly accurate, especially when utilization was determined from weight-distribution curves established from plants comparable in size to those within the utilized area. The ocular-estimate-by-plot method was the easiest to use and gave generally satisfactory results. Individual errors were high with this method, however, and the training of estimators is an important phase of the use of this system. The percent-of-plants-grazed method was unsatisfactory for direct determination of utilization on this type of range.

Procedures: Study 2. A second study, covering the period 1954-58 was concerned with the influence of early season clipping on the productivity of native mixed prairie. In this study replicated 1-meter-square plots were clipped at successively later dates in the spring and early summer. One set of plots was clipped on May 10, a second set on May 20, the third on May 30, and so on at successive 10-day intervals through June 30. Vegetation was clipped at a height of 1 inch.

Progress: Study 2. Four years after the initiation of clipping the plots that were first clipped on May 10 were producing only about half as much forage as those first clipped on June 30 of each year. Actual yields were 373 lbs. per acre for May 10 quadrats and 809 lbs. per acre for June 30 quadrats in a second type.

Under all dates of clipping there was a reduction in density of the taller grasses and an increase in cover of the shorter grasses, indicating a tendency for the conversion of the original mixed-grass vegetation to a short grass type. The clipping treatments resulted in vigor injury on all plots, and total production was considerably reduced on all plots during the period of the trial.

STUDY 3. Phenological measurements on 22 grasses and 35 forbs have been carried on during the period of this study. This phase of the work is being continued. In addition, yield increment studies of blue grama grass and western wheatgrass are being made. The influence of the micro-climate on growth and development of the native grasses is being given considerable attention at the present time, and a site in the native grass vegetation has been instrumented to compare wind velocity, temperature, relative humidity, and evaporation at respective heights of 5 inches and 5 feet. Soil moisture and soil temperatures at 6-inch intervals to a depth of 3 feet are also determined.

OKLAHOMA

Title: SUMMARY OF BRUSH CONTROL RESEARCH WITH HERBICIDES FOR NATIVE GRASS IMPROVEMENT IN OKLAHOMA

Leader: Harry M. Elwell, Agricultural Research Service. Cooperating with Oklahoma State University

Progress: Aerial and Ground Spraying: Research aerial applications were started in 1952 and commercial ranch aerial spraying with low-volatile esters of 2,4,5-trichlorophenoxy acetic acid (2,4,5-T) in 1955. The low-volatile ester formulations have proved effective for control of post, dwarf, chinquapin, and blackjack oaks and scrub hickory. When these species are suppressed 70 per cent or more by 2,4,5-T native grasses readily re-establish themselves through natural seeding and stooling and increased 2 to 4 times in production. Comparable rates and types of applications with low-volatile esters of 2, (2,4,5-trichlorophenoxypropionic acid) silvex in southwestern Oklahoma was about 15 per cent more effective than 2,4,5-T in controlling post oak. The 2,4,5-T has given slightly better suppression of other oaks and scrub hickory in the eastern half of Oklahoma.

A spray of the herbicide plus enough good-quality (water-free) oil to make 1 gallon with 4 gallons of clean water, applied at 5 gallons per acre in a 40-foot swath, has given good foliage coverage. May 20 to July 1 has been the best period for spraying brush. Coarse droplets dispersed from a seven-nozzle boom mounted at the back edge of an airplane wing have aided in control of drift when applied under wind velocities of 5 miles per hour or less with moderate air temperatures and humidity conditions.

Post, black jack, and dwarf chinquapin oaks and hickory recovering from severe drought have been effectively killed by a single 2-pound-per-acre application of low-volatile ester of 2,4,5-T. However, with normal or above-normal precipitation two foliar applications, spaced a year or 2 apart, have been necessary for effective killing of oaks and scrub hickory.

Deferred grazing from May 1 to October 1 for 2 years has permitted the native grasses to develop a good stand and growth on treated brush land. A dense sod of grasses developed on treated brush land has aided in preventing the re-invasion of brush after herbicide treatments.

Esters of silvex or 2,4,5-T in foliar sprays at rates recommended for oak control have not effectively suppressed elms, hawthorn, ash, huckleberry, greenbrier and buck brush.

Ground Foliar Spray: Post, blackjack, and dwarf chinquapin oaks have been effectively controlled with 3 pounds of 2,4,5-T ester per 100 gallons of water. The spray should be applied to cover leaves and terminal twigs of entire plants thoroughly. On hard-to-kill species (scrub hickory, elms, dogwood, hackberry, and chittamwood) 4 pounds of 2,4,5-T acid per 100 gallons of water has given more effective control. Persimmon suppression has been best with 1 pound of 2,4,5-T per 100 gallons of water. Two or three annual retreatments with the same amount of 2,4,5-T has been required to obtain satisfactory suppression of most of the species. Post, blackjack, and dwarf chinquapin oak regrowth on mechanically cleared land has been more difficult to control, especially sprouts less than 4 years old than undisturbed growth with esters of 2,4,5-T in foliar spray.

Buck brush, sumac, willow and sand plum have been effectively controlled with 2 pounds of 2,4-D ester per 100 gallons of water applied as a wetting foliage spray. Most of the 2,4,5-T ester formulations tested have not given effective control of buck brush.

Salt cedar has not been effectively suppressed with any of 2,4-D, 2,4,5-T or 2,3,6-trichlorobenzoic acid formulations applied as foliar sprays. Fair control of salt cedar has resulted from 1 pound of ammonium sulfamate (95% concentration) per gallon of water applied as foliar applications.

Ammonium sulfamate at the same rate plus recommended spreader sticker has generally given good control of all woody species. However, annual retreatments have been necessary to obtain good suppression of most woody species. The time and weather conditions for ground foliar spraying are the same as for aerial spraying.

Basal bark, injection and Soil Applications: Most of the broad-leaf woody species have been satisfactorily suppressed with 12 to 16 pounds of 2,4,5-T acid in 96 to 97 gallons of diesel oil or kerosene applied to encircle and thoroughly wet the lower 10 to 12 inches of the bark and permit some runoff into the soil around each plant. For injection treatments, the most consistent results have been with 40 pounds of an ester of 2,4,5-T per 90 gallons of either diesel oil or kerosene. Injections are generally most effective when spaced near the soil 1-inch apart to encircle each plant. Each incision should be filled with the herbicide-oil-mixture. This type of treatment has given good kill of hard-to-suppress woody species.

Effective killing of post, black jack and dwarf chinquapin oaks, elms, hickory, hackberry, chittamwood, cottonwood, and locust has been obtained with either basal-bark or injection treatments during winter (December 1 through March 15). Persimmon has not been consistently killed with basal-bark treatments. Clean-up applications have been necessary to eliminate missed or resistant plants.

Soil treatments with 3-(p-chlorophenyl)-1, 1-dimethylurea (monuron), or 3-(phenyl)-1, 1-dimethylurea (fenuron) in 80-percent wettable-powder applied at 1/8 to 1/4 pound of product per gallon of water have been more effective than equal amounts of these herbicides in pellets. These herbicides, in powder or pellets, have given more effective control of brush on deep, sandy soil than on clay loam. For post, blackjack, and dwarf chinquapin oak control, the effective rate of these herbicides starts at about 6 pounds of active chemical per acre with the amount increasing to 10 pounds per acre of active ingredient for elms and persimmon on sandy soils. Higher rates are required on heavier soils.

Most effective applications of monuron or fenuron has been from January to March. Some control has been obtained from application during other seasons of the year, but the chemicals are deteriorated by intense sunlight.

Studies of granular 2,4-D; 2,4,5-T; 2,3,6-TBA; monuron-trichloroacetic acid combination, and fenuron-trichloroacetic compound are under-way. Preliminary results of soil applications have not shown any of these granular materials to be effective for control of brush.

Chemical Control of Hardwood for Pine Release: September 1957 aerial applications of 1.5 pounds of 2,4,5-T acid per acre in a low-volatile ester and an amine formulation severely defoliated short leaf pine. The same rate of 2,4,5-T in the two formulations applied in September 1958 severely twisted and discolored the top 1/3 of seedling pines. The pines recovered from the 1957 and 1958 herbicide effects and appeared to make normal growth during the spring and summer of both years. The September treatments did not effectively control post, and clackjack oaks, hickory, elms, greenbrier, haws and wild blackberries. Aerial applications of 1.5 pounds of 2,4,5-T acid per acre per year in May 1958 and 1959 as low-volatile ester and amine caused some browning of pine foliage but not defoliation. The seedling pines were not noticeably affected by the May herbicide applications. Good foliar suppression of post, and blackjack oaks and hickorys was obtained with the 1.5 pounds of a low-volatile ester of 2,4,5-T applied in May 1958 and again in 1959. The amine formulation of 2,4,5-T caused only fair foliar suppression of hardwoods.

Native grass recovery was fair on areas treated with a low-volatile ester of 2,4,5-T where the pine stand was open. Dense stands of pines and areas thickly set to seedling pines excluded the grasses.

Title: WEED CONTROL WITH HERBICIDES FOR IMPROVEMENT AND MAINTENANCE OF NATIVE GRASSES

Leader: Harry M. Elwell, Agricultural Research Service, CRD

Progress: Pre-emergence treatments: High-volatile and low-volatile esters of 2,4-dichlorophenoxyacetic acid (2,4-D) at 1 pound of acid per acre in March 1959 applications gave good suppression of western ragweed. The control in 1959 was 8 times as good as that from similar applications in 1958. Granular 2,4-D at 3 pounds of acid per acre applied in March 1959 also gave fair ragweed control.

The herbicides 3-(p-chlorophenyl)-1, 1-dimethylurea (monuron), 3-(3,4-dichlorophenyl)-1, 1-dimethylurea (diuron), 2,3,6-trichlorobenzoic acid (2,3,6-TAB), 2,2-dichloropropionic acid (dalapon), 4-(2,4-dichlorophenoxy) butyric acid 4-(2,4-DB), 2,4-dichlorophenoxyacetic acid (2,4-D) applied as pre-emergence treatments in 1959 even at 5 pounds of active chemical per acre did not have any residual effects on western ragweed in 1959.

Foliage applications: Low volatile and high-volatile esters of 2,4-D at 1 pound of acid per acre produced effective and consistent weed control during the past 2 years in native grass ranges and pastures. On extremely weedy ranges and pastures two or possibly three sprayings with each spaced a year apart will be necessary to eliminate annual weeds and suppress perennial ones. Deferred grazing (May to October 15) the years of treatments should reduce the number of treatments needed. Most weedy ranges and pastures are heavily infested with seeds of both annual and perennial weed species that generally remain viable for several years. These seeds germinate during years of favorable moisture.

Title: EFFECT OF HEIGHT AND INTENSITY OF CLIPPING ON SEVERAL GRASSES

Leader: W. C. Elder, Department of Agronomy

Progress: Pure stands of El Reno and Tucson side-oats, Indian and switchgrass, big, little and K. R. Bluestem were planted on the Blackwell Lake area in 1949. Cattle were used to determine the palatability of these grasses for four years. In the spring of 1955 clipping studies were set up on these pure stands that were well established. The soil is a Norge loam with 1 to 3 per cent slope. The clipping procedures were:

1. Clippings made in duplicate at 2 & 4" height, 30-day intervals
2. Clippings made in duplicate at 2 & 4" height, 60-day intervals
3. Clippings made in duplicate at 2 & 4" height, in July
4. Clippings made in duplicate at 2 & 4" height, in January or February

All vegetation was clipped from all treatments in January or February.

The objective of the study was to determine the effect of the different treatments upon the stand, density, botanical composition and yield for the different species or strains.

Total production does not denote quality of forage but one clipping made in July always produced the greatest yields. Clipping at the 2" height increased yields approximately 25% over the 4" height cuttings, a large amount of dry matter was lost from July until January.

Title: EFFECT OF FERTILIZATION ON NATIVE GRASS PASTURES IN OKLAHOMA

Leader: Wayne W. Huffine, Department of Agronomy

Progress: Ranges in Oklahoma were generally heavily infested with weeds in 1957. This was the result of a drouth from 1952 through 1956 and subsequent overgrazing in this period plus the abundant rainfall early in 1957 that encouraged germination of the weed seeds. The weather in 1957 and 1958 was favorable for the recovery of grasses as evidenced by a reduction in weed growth in 1958 of about 50% when compared to the same area the previous year.

Drouth and overgrazing are not the only factors that bring about weed infestation of native ranges as shown by earlier work at this station, and supported by this study, in which the weeds were definitely increased through the repeated use of fertilizers.

Pastures established in 1935 and 1936 on the Red Plains Conservation Experiment Station near Guthrie, Oklahoma were used in this study. The land on which these pastures were developed was described as eroded and virgin in the 1956 annual report from that station. The history and use of the land hardly warrants the term virgin; therefore, will be referred to hereafter as unplowed and cleared. The eroded area was land which had been abandoned about 20 years ago for crop production because of erosion and allowed to return to native grass. The unplowed and cleared area had been covered with native grasses and scrubby oaks (Quercus spp.) originally. The oaks were removed in 1935 and 1936 and in 1939 grazing was begun on both areas as a single unit. In 1952 the two areas were separated by fencing into pastures referred to as eroded and unplowed-cleared. Each of these was divided equally with one pasture of each land condition being fertilized with 300 pounds of 0-20-0 in 1952 and again in 1955 plus an annual application of 33 pounds of actual nitrogen per acre applied in late May of each year until the grazing study was terminated at the end of the 1956 season. None of the pastures were grazed in 1957 or 1958.

In August of 1957 and July, 1958 ten random samples were taken from each pasture to determine the botanical composition by hand separation. Each of the plots was 30 square feet in size in 1957 and the forage was clipped two inches above soil surface. The height of clip was the same in 1958 but the plot size was reduced to 18 square feet. The predominant grasses were found to be big and little bluestem (Andropogon gerardi and A. scoparius), switch (Panicum

virgatum), Indian (Sorghastrum nutans), sideoats and blue grama (Bouteloua curtipendula and B. gracilis), splitbeard bluestem and silver beardgrass (Andropogon ternarius and A. saccharoides). A wide range of weeds were present, but the most commonly found were annual plantain (Plantago spp.) black-eyed Susan (Rudbeckia hirta), maretail (Erigeron canadensis), annual broomweed (Amphiachyris dracunculoides), and western ragweed (Ambrosia psilostachya). Legumes present were catclaw sensitive briar (Schrankia uncinata), lead plant (Amorpha canescens) and Cassia species.

The predominant grass species in the pastures developed on eroded land where silver beardgrass and splitbeard bluestem. The desirable tall grasses predominated in the unplowed-cleared pastures with very little silver beardgrass or splitbeard bluestem present.

Table 1. Botanical Composition of Four Native Grass Pastures on the Red Plains Conservation Experiment Station

Pasture - (Initial Land Condition & Treatment)	Pounds of Oven-Dry Matter Per Acre ^{1/}					
	Grass		Weeds		Legumes	
	1957	1958	1957	1958	1957	1958
Eroded No Fertilization	754	847	229	89	13	3
Eroded Fertilized	714	504	821	476	45	39
Unplowed-cleared No Fertilization	1230	1311	541	185	23	0
Unplowed-cleared Fertilized	982	1408	1294	423	1	5

^{1/} Average of ten samples from each pasture.

The total production of oven-dry material per acre each year was higher where fertilizers were used. This greater yield resulted from more weed production primarily, as there was very little, if any, increase in legume yield and only in 1958 was there an increase in grass production and this was less than 100 pounds per acre. Native legumes contributed little, if any, to the total yield.

A greater proportion of weeds was found each year in the pastures developed on the unplowed-cleared land than on that which was eroded. The non-fertilized unplowed-cleared pasture had 30% of its total yield in the form of weeds in 1957, while 57% of the total yield was weeds in a similar pasture that was fertilized. In 1958, weeds produced twice as much vegetation on the fertilized unplowed-cleared pasture as on the non-fertilized. Results obtained from the other land area showed two to five times more weeds produced by weight on the eroded fertilized pasture than on the unfertilized one.

Title: PERENNIAL WARM-SEASON GRASSES ADAPTED TO SEMI-ARID AND ARID REGIONS

Leader: W. R. Kneebone, Agricultural Research Service

Progress: Work with the warm-season grasses includes the effect of seed-size on seedling vigor, improved resistance to seed-shattering, increase in nutritive value of winter-cured forage, and improvement in palatability of adapted species.

- A. There has been some doubt as to whether increased seedling vigor was due to factors associated with large seed or whether large seed size in itself was important. A 1959 study involving reciprocals from a large by small seeded sand bluestem cross showed conclusively that seed size in itself is effective in promoting seedling vigor. Clone 36 has seed twice as large as clone 32. Planted at 1-1/2" depth in the greenhouse, seedlings from 36 x 32 emerged at 12.5 days and were 50 mm. tall after 21 days. The genetically equivalent 32 x 36 seedling population emerged at 14 days and averaged only 5 mm. tall after 21 days.
- B. Shatter resistance of certain sand bluestem plants in 1958 proved equally good in 1959. The best of these plants will be used as parents to incorporate this character into new breeding lines.
- C. Three years of sampling winter-cured sand bluestem leaves for protein content was completed in 1959. A range of 1.99 to 3.90 per cent protein which is significantly different at the 5% level, demonstrated potentials for breeding.
- D. Further grazing of the weeping lovegrass palatability trial showed that the same strains were preferred in 1959 as in 1958.
- E. Progress is being made in the development of a superior, sexually-propagated type of sideoats grama.

Title: CYTOGENETICS, BREEDING BEHAVIOR AND TAXONOMIC RELATIONSHIPS OF GRASS SPECIES

Leader: W. R. Kneebone, Agricultural Research Service

Progress: Several studies have suggested that vigorous plants might be less subject to environmental fluctuations than non-vigorous plants. Data were obtained first in 1959 from a comparison of a vigorous high-combining clone of sand bluestem with a weak low-combiner. Intracultural variances for plant height, plant diameter, seed size, and seed set were compared. No significant differences could be shown. Clonal averages were distinctly different in all characters. The more vigorous clone with its higher values tended to have slightly greater variances. Growth curves based upon biweekly measurements were parallel, although the later, vigorous clone continued growth after

the curve for the weak clone had flattened out.

Four Indiangrass plants from a light dark glume cross failed to set selfed seed in the greenhouse and each was set out under isolation in the field. A fair amount of seed was obtained from each, the first time that any inbreeding approach has worked. Numerous attempts at bagging have failed. The glume color hypothesis attempted in 1958 was disproven by additional data in 1959, but an answer finally seems to be in sight.

Stoloniferous types of blue grama and sideoats grama obtained from several collections in 1959 will be increased in 1960 to study this relatively rare character for these species.

Selections of sand bluestem made in 1959 will be combined in 1960 for the first cycle of a comparison between two recurrent selection systems. Effectiveness of the two systems will be measurable on seed size and seed set as well as plant types since this material has been very thoroughly catalogued and selected for these characters.

Title: PERENNIAL COOL-SEASON GRASSES ADAPTED TO SEMI-ARID AND ARID REGIONS

Leader: W. R. Kneebone, Agricultural Research Service

Progress: Poa selections set out in 1958 for selfing and crossing studies failed to flower satisfactorily and were moved to a better location in 1959. Genetic studies on rust resistance will be initiated in 1960.

Blue grama test plots transplanted 1958 Woodward. Air-dry forage in pounds per acre, average 3 reps.

Source	1 Cut	1959			1958-59 Average
	1958	6/18	8/13	Total	
Marfa	1770	2480	1333	3813	2792
Syn. 40	1560	2080	1113	3193	2376
Syn. 20	1640	1993	1173	3167	2404
Common	1060	1820	1193	3013	2036
Capitan	1770	2000	920	2920	2345

Bermudagrass test plots at Woodward. Air-dry forage in pounds per acre, 1959. Average 2 reps.

Source	1 Cut 1958	1 Cut 1959	1958-59 Average
Midland	2060	3187	2624
Common	1341	2482	1912
Expt. 2	1846	2364	2105
Greenfield	823	1971	1397
Expt. 1	1169	1749	1459

Sand bluestem strain trials at Woodward 1959. Air-dry forage yields in pounds per acre 1 cut. Plots were transplanted seedlings spaced 1 foot each way. Rows were 44" apart, plants 1' apart in row.^{1/}

Source	1958 Test (5 reps)	1957 Test (3 reps)	Plot average	1957 Row test (4 reps)
Hi 8	6224	3233	4728	9130
Cheyenne	5652	4340	4996	----
Hi 4	5144	4520	4832	9382
Woodward	4900	3107	4004	8654
Lo 4	4344	4707	4526	----
Lo 8	3776	3653	3714	6205

^{1/} 1957 Tests bulked OP seed from parents. 1958 tests from bulked seed of parents grown together under isolation.

Sideoats grama test seeded at Woodward, 1957. Air-dry forage in pounds per acre. Average 4 reps.

Source	1 Cut 1959
Block 3	3015
Block 2	2775
W2	2515
Block 4	2460
W3	2305
Block 1	2140
Coronado	2085
W1	2080
Temple	1905
W4	1775
El Reno	1690
Hope	1595
Tucson	1540

Switchgrass test seeded at Woodward, 1957. Air-dry forage yields in pounds per acre. Average 4 reps.

Source	2 Cuts 1958	1 Cut 1959	1958-59 Average
Caddo	5330	2250	3790
Bottom land	4350	1960	3105
Common	3970	1915	2942
Woodward sand bluestem	3530	2020	2775

Sand bluestem clonal test, percentage protein in leaves, winter forage (January), figures are averaged from 4 replicates

Clone	1957	1958	1959	Average
Woodward 4*	4.09	4.50	2.38	3.66
9	4.84	3.36	2.82	3.67
19	3.28	2.75	1.96	2.66
27	2.84	2.44	1.64	2.31
30	4.34	3.82	2.83	3.66
34	3.46	3.80	2.45	3.23
36	2.78	2.53	1.46	2.26
Kansas 1	2.82	2.50	1.66	2.33
2	2.63	2.26	1.33	2.07
3	3.94	3.66	2.65	3.41
4	4.30	4.44	2.97	3.90
5	2.39	2.49	1.52	2.13
6	2.36	2.16	1.46	1.99
7	2.30	2.25	1.47	2.01
8	2.69	2.74	1.89	2.44
9*	3.30	3.42	2.05	2.92
10	2.63	2.78	1.78	2.40
12	2.75	2.18	1.60	2.17
13	3.36	2.36	1.67	2.46
14	4.24	3.83	2.70	3.59
L.S.D. .05	.70	.87	.76	.45

*Three reps only, missing plot calculated.

Effect of caryopsis size and planting depth upon growth of sand bluestem seedlings in greenhouse flats. Figures are averages from 4 reps.

Seed source	500 seed Wt.	1/2" depth			1" depth			1-1/2" depth		
		Days to emer- gence	Ht. in mm 14- day	21- day	Days to emer- gence	Ht. in mm 14- day	21- day	Days to emer- gence	Ht. in mm 14- day	21- day
36x32	1.89	8.0	31.2	39.5	6.8	30.0	64.2	12.5	25.8	50.0
36x34	1.70	9.5	32.2	60.0	10.2	27.8	59.5	11.5	21.8	69.5
32x36	.80	12.2	18.2	44.5	12.8	16.2	41.2	14.0	3.0	5.0
32x34	.84	9.0	24.2	48.8	10.8	18.0	37.8	10.8	14.2	40.0
32x35	.79	10.8	17.0	49.5	10.2	21.2	40.5	12.2	20.5	46.2

OP seed from
36x32 progeny

153-12	1.45	8.8	26.2	65.8	9.8	27.0	63.8	11.2	18.5	55.0
153-15	1.50	7.8	37.0	68.8	7.8	34.8	66.2	8.8	25.2	62.5
153-17	.88	8.0	26.5	56.2	8.5	28.2	60.0	9.5	20.5	48.5
153-20	.95	8.5	23.0	55.0	8.8	23.8	52.5	10.2	19.2	50.0

Title: EFFECTS OF FW-450 AND DALAPON ON POLLEN PRODUCTION AND SEED SET IN SAND BLUESTEM (ANDROPOGON HALLII HACK.)

Leader: W. R. Kneebone, Agricultural Research Service

Progress: Studies were conducted in an irrigated seed production field of Woodward sand bluestem planted in 3 foot rows. Three foot sections of row were marked off and treatments were applied to every other section. Plots were sprayed with a Hudson sprayer until all parts of the plants were wet. Each plot was enclosed in a screen of waterproof building paper open only on the spray operator's side. Thus the 3-foot buffer strips and buffer rows were untouched by any treatment. Three solution strengths of FW-450 and of Dalapon were applied on two different dates, July 9, 1959 at early heading and July 20, 1959 at early bloom. Solution strengths were .05, .15, and .45 per cent. Check plots were sprayed with plain water. No surfactants were used. The experiment included 6 randomized blocks in a complete factorial design. Dehiscing anthers were collected from the .45 per cent plots and check plots 2 weeks after the first spraying. Pollen stainability in iodine potassium iodide solution was used as a measure of pollen viability. Seed from each plot was harvested in October and seed set measured by the percentage of rough seed weight which was actual caryopses.

With the exception of the .45 per cent Dalapon spraying there was little effect from any treatment. The heaviest Dalapon yellowed some of the plants for a period following spraying and reduced final seed sets. No observable effects on anther development were noted. There might have been a slight effect by Dalapon upon pollen viability although the figures for percentage

unstained pollen did not differ significantly. Spot checking following this one pollen count gave no suggestion that further complete checks of all replicates would be worthwhile.

Apparently neither FW-450 nor Dalapon offer much promise as experimental selective male gametocides for sand bluestem. Since seed set was low in 1959 it is possible that the lower concentration solutions might have shown some reduction of seed set if caryopses percentages had been higher in general.

Percentage unstained pollen from sand bluestem plants sprayed to wetness 2 weeks previously with listed solutions. Figures are averages of 6 replicates.

Percentage unstained pollen	.45% Dalapon	.45% FW-450	Water
	24.0	22.0	22.0

Effects of FW-450 and Dalapon upon seed set (as measured by caryopsis percentage in harvested seed material) of irrigated Woodward sand bluestem. Plants were sprayed to wetness with solutions of indicated strengths. Figures are averages of six replicates.

Rate	Caryopsis percentages				Caryopsis percentages with check as 100 ^{1/}			
	FW-450		Dalapon		FW-450		Dalapon	
	7/9/59	7/20/59	7/9/59	7/20/59	7/9/59	7/20/59	7/9/59	7/20/59
Water chk.	12.4	11.6	12.4	11.6	100	100	100	100
.05	12.1	11.5	13.2	13.1	102	108	108	118
.15	12.4	12.7	12.9	12.8	106	116	109	116
.45	13.2	11.3	9.6	10.3	109	102	76	93

^{1/} Using check plots in each replicate, then averaging replicates.

Title: IMPROVING OLD WORLD BLUESTEMS

Leader: Jack R. Harlan, Agricultural Research Service.
Cooperating with Oklahoma State University

Progress: The development of adapted materials for both range lands and tame pastures is the objective of the Old World Bluestem program. Basic work so far conducted is applicable to both grassland areas and in 1958, was reported primarily under the pasture improvement section.

A. Bothriochloa intermedia X750, a self-sterile sexual tetraploid produced in our nurseries was used extensively in 1959 as a female parent. For the first time in 8 years of effort, hybrids were produced with Caucasian bluestem. Several F₁'s of this cross succumbed to the delayed lethal characteristic of crosses with Capillipedium spp. which confirms our impression that Caucasian bluestem is really a Capillipedium. X750 was also crossed with B. ischaemum, Dichanthium annulatum, D. fecundum, and B. intermedia. Some of the F₁'s with a B. ischaemum from Turkey were exceptionally vigorous and it is hoped that some may be both winterhardy and sexual. Such plants would be the next step in a break-through toward breeding adapted material for the Great Plains.

- B. Dicanthium fecundum is an Australian endemic with perfect pedicellate spikelets. Despite the fact that this character is considered diagnostic for the subtribe Saccharinae, its inheritance appears to be relatively simple.
- C. Unexpectedly, D. fecundum proved to be quite interfertile with the sexual D. annulatum (X98); the perfect pedicellate spikelet was dominant in F₁ and segregated 1:1 in a backcross population.
- D. Crosses between the Tropical type of D. annulatum represented by X98 and the Mediterranean type represented by 4390 from Tunisia produced two significant results. (a) About 15% of the F₂ population from a tetraploid F₁ were diploids. We now have reason to wonder if our diploid accessions of this species are original or derived. (b) One of the F₁'s of the above cross was a hexaploid and a very near synthesis of D. papillosum. The only difference we can see at present between the synthesized plant and naturally occurring D. papillosum is that the former is sexual and the natural ones apomictic. We now have a sexual hexaploid to add to the growing list of potential parents in the breeding program.
- E. In evaluation work, even as seedling plots, some of the air-dry weights indicated yields in excess of 5 tons per acre.

Title: RANGE GRASS SEED TECHNOLOGY

Leader: Robert M. Ahring, Agricultural Research Division
Cooperating with Oklahoma State University

Progress: Storage Studies: Seed storage studies on native and introduced grasses are being conducted on small quantities of very high quality seed. These studies are confined to room temperature on both caryopses and rough seed. Objectives are to measure the effect of (1) various types of storage containers, (2) various insecticides mixed thoroughly with the stored seed, and (3) a small bag of a desiccant (Activated Alumina) placed inside the storage container, in maintaining seed viability for prolonged periods.

Bromegrass - (Bromus inermis): Upon the completion of four years of study, there was practically no viability left in bromegrass seed stored at room temperature as shown in the table below.

Viability of bromegrass seed at intervals during storage in
three types of containers with and without a desiccant

Years in Storage	Average Percent Germination				
	Cloth	With Desiccant		Without Desiccant	
		Laminated	Carton	Laminated	Carton
0	93	93	93	93	93
1	94	95	95	95	94
2	81	77	78	78	78
2-1/2	46	54	50	58	58
3	25	38	32	36	44
3-1/2	5	11	7	14	12
4	0.37	0.5	0.5	2.25	1.87
4-1/2	0.0	0.2	0.0	1.50	0.5

The most rapid decrease in viable seed content was found in the seed stored in muslin cloth bags. No loss in the germination capacity was observed during the first year of storage. A range of 10 to 17 per cent of the initial germination was lost during the second year. It is after the 2-year storage period, that the seed stored in this type of container shows a marked decrease in the amount of viable seed. This same trend is evident in the other containers, with and without the desiccant, but is reduced to a slower rate.

The humidity of the surrounding atmosphere may have contributed to the rapid decrease in viable seed stored in the porous muslin bags. Whereas, the humidity within the sealed and non-porous laminated bags and carton containers would fluctuate less, being determined more by the moisture content of the seed.

The duration of the viable bromegrass seed stored at room temperature is four years. A period of rapid deterioration of the seed occurs after two years of storage. This curve of deterioration is slowed, but exhibits the same trend, when stored in air-tight laminated bags or carton containers. The value of a desiccant added to the container was not evident. Insecticides, Aldrin, Dieldrin, and Lindane at the rates used had no measurable effect on seed viability during the period of storage.

Blue grama: The viable seed content of both caryopses and rough pure seed forms of blue grama has completely deteriorated after four and half years of storage. This rate of deterioration is shown in the following diagram for the check treatments:

Months of Storage	+ percent decrease from the initial germination	
	<u>Rough Pure Units</u>	<u>Caryopses</u>
12	0.0	+ 7.0
22	+ 43.9	- 42.8
27	+ 13.4	- 90.0
34	- 53.6	- 96.0
39	- 76.8	- 96.0
48	-100.0	- 98.4
52	-100.0	- 99.2

A rapid decrease in the viable seed content is found in the caryopses following the first year of storage. Whereas, for the same period of time, based on the initial germination percentage, the seed stored in the rough pure form had not decreased but germinated higher than the original estimate. A decrease from the original germination estimate was not found in the rough seed form until the 34th month. In comparing the differences in the original germination estimates of 41 and 63 percent for the rough seed and caryopses respectively and adding this difference to each germination interval for rough seed, the difference between the two forms of stored seed is not very great.

The insecticides and rates used mixed thoroughly with the seed did not have any phyto-toxic effect on the young seedlings, nor have a detrimental effect on germination.

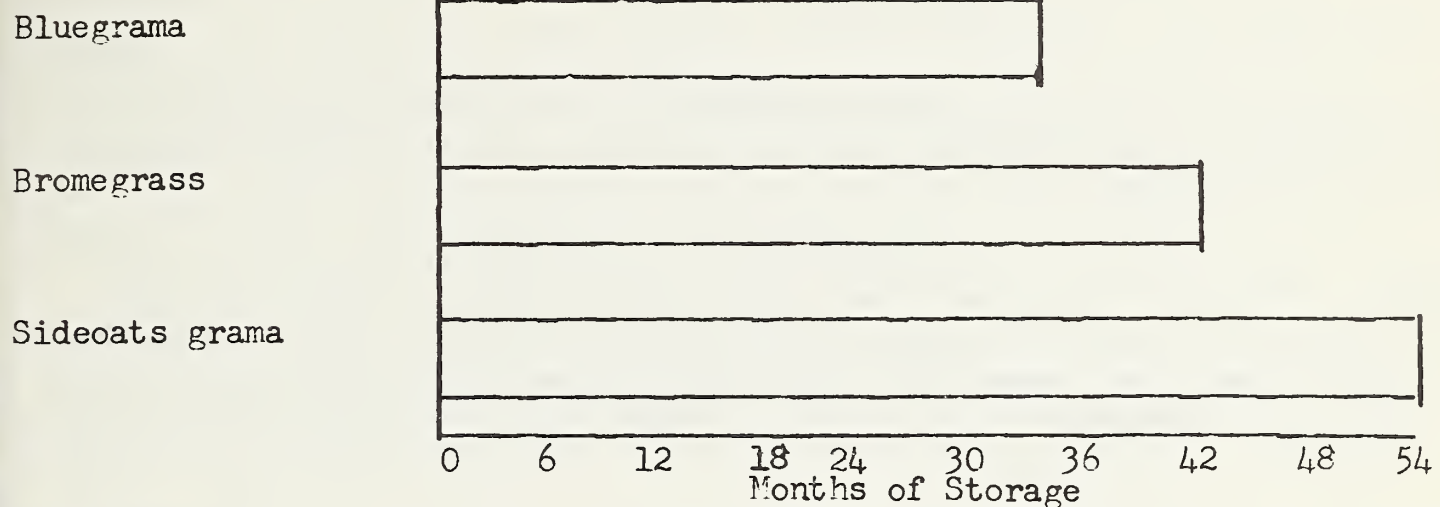
Sideoats grama: Insects such as the carpet beetle are the main problem involved in storing seed in the caryopses form. This study was to measure the longevity and the effect insecticides mixed thoroughly with the caryopses have on the seed viability of sideoats grama.

The insecticides used in all studies were wettable powders. Their toxic effect to the seed, if any, should be closely correlated to the seed storage conditions and the seed moisture and/or oil content.

Where there was no evidence to indicate insecticide toxicity to the seed of blue grama, the opposite seems to be true in sideoats grama. With the exception of lindane, 20 percent wettable powder, the germination of sideoats grama was affected by the insecticide treatments. The effect due to the insecticide treatments was evident only after the 2nd year of storage. Since there was no evident insect problem during storage the differences found between treatments can be attributed to the toxic effect of the insecticide.

The work that has been done on seed storage on these three grasses to date can be summarized as follows:

Number of months of seed storage at room temperature required for blue grama, sideoats grama and brome grass to lose approximately 80% of their initial viability.



Switchgrass: The viability of switchgrass seed stored under various conditions has shown only a slight decrease in germination from its initial germination capacity.

Sand bluestem: The presence of a desiccant (Activated Alumina) as part of the storage treatment seems to make a great difference in maintaining viable sand bluestem seed. Seed stored as caryopses in the presence of a desiccant have maintained a viable seed content 50 percent greater than the same form of seed stored without a desiccant. The value of the desiccant is also evident in the rough seed form, after two years of storage, as shown below.

Average Percent Viability

Months of Storage	<u>Caryopses</u>		<u>Pure Rough Seed Units</u>	
	<u>Desiccant</u>		<u>Desiccant</u>	
	Without	With	Without	With
0 Initial	79	79	74	74
6	73	72	90	89
12	58	74	86	83
18	52	78	64	64
24	42	74	68	67
34	19	43	42	58

The only indication of a harmful effect of insecticide treatments on seed germination was found in the caryopses stored with a desiccant. Lintox (B_4), used at the rate of 2 grams per pound of seed, has consistently germinated much lower than the other treatments at each germination interval.

Bothriochloa ischaemum: A survey of the germination requirements of the Bothriochloa ischaemum complex was conducted during 1957, 1958, and 1959. The seed of the material used were grown in the Andropogoneae nursery at the Oklahoma Agricultural Experiment Station, Stillwater, Oklahoma. From approximately 60 accessions of the species being grown in the nursery, representing the entire range of it's distribution, a representative sample of 25 accessions have been studied.

The B. ischaemums in general seem to respond best to alternating temperatures. A few accessions have little preference to the temperatures used whether alternating or constant.

Response to pre-germination treatments seems to fluctuate between years and treatments. The most consistent data were for untreated, rough seed units which almost without exception gave the lowest germination. Almost any treatment seemed to get some response in improved germination. On the whole the most consistent treatment for increasing germination was 2% KNO_3 without any other treatment.

The degree of seed dormancy varies between the B. ischaemum accessions and the year grown. With the exception of only a few accessions depending on environment, the rough pure seed units receiving no pre-treatment had the lowest germination percentage. Extracting the caryopses from the appendages was enough to stimulate germination considerably over the rough pure seed units. Inhibition of germination was evidently due in part to the enclosing appendages. Treatment 5 and 6 gave some indication that this is true but more work is needed to determine concentrations needed of both these treatments to inhibit seed germination to the level of the rough seed counterpart.

The highest number of abnormal seedling is more frequently found in pre-chilled treatments. The frequency of abnormal seedling varies as to treatment and germination environment. Frequently the most optimum treatment and temperature also produce the highest number of abnormal seedlings. KNO_3 used as a moistening agent produces abnormal root development in some accessions such as King Ranch and 3457, but is not consistent in all environments. $\text{Ca}(\text{NO}_3)_2$ might be as effective in increasing germination without producing so many abnormal seedlings.

The frequency of twinning is also dependent upon environment and pre-germination treatment. A few accessions produced the greatest number of twins in the constant 30° and in the alternate $20-35^\circ \text{C}$. environment.

The B. ischaemum accessions seem to be divided into low, medium and high producer's of twins. The frequency of twinning is lower in King Ranch blue-stem than in all other reported here.

Low frequency group	=	King Ranch and 3457
Med. "	=	562-b, 6582, and 5110
High "	=	7044, 6985, 7041, and 6982

Triplets occur in nearly all accessions but are rather infrequent. A great deal of variable twin types are found especially in accession 6985.

Title: RANGE GRASS SEED PRODUCTION

Leader: Robert M. Ahring, Agricultural Research Service, CRD.
Cooperating with Oklahoma State University

Progress: The work under this project is being conducted under irrigation at the El Reno Livestock Research Station. Gated pipe is now being used replacing the time consuming ditch irrigation system. The seed processing plant has been rearranged for more efficient handling and processing of grass seeds. An electric fence system has been set up to study grazing of livestock in relation to grass seed production and preference of the animals to many of the newly selected grasses being grown for increase.

Establishment of new materials and re-establishing of older stands have included Indiangrass (Sorghastrum nutans), Sand bluestem (Andropogon hallii), Turkish wild alfalfa (Medicago sativa), vetch (*Vicia sativa*), 6580 (Bothriochloa intermedia) and Klein grass (Panicum coloratum).

Seed production studies on native and introduced grasses have been revised during the past year. Less emphasis is being placed on fertility requirements, but fertility work will remain a part of the overall studies.

Since a number of preparations had to be made, only the preliminary soil studies (conducted by Dr. Joe Gingrich) have been started. The following studies are hoped to be in full swing during the coming season.

Cultural and management practices for seed production on new and old established stands.

Objectives: To measure the effect of age of stand on the production of forage and seed. The changes in soil environment imposed by the plant itself, i.e. root density, root exudates, root ion absorption and fixation.

To study the effects of various sub-tillage practices on yield of old established stands by measuring the effect of various treatments on the soil physical properties, soil moisture distribution, crop moisture requirements and crop moisture extraction patterns.

Grass and field crop compatability in rotation.

An attempt will be made to determine the number of years one can expect good grass seed yields from pure stands produced under irrigated and dryland conditions. The knowledge of the value of a grass-crop rotation is important in furthering the uses of improved native grasses and the availability of high quality seed.

Objective: To measure the number of years maximum grass seed yields to be expected from newly established stands.

The response of other crops planted in rotation on land after 1, 2, 3, 4, and 5 years of continuous grass seed production.

The past year has consisted of establishing the perennial crops, alfalfa, sideoats grama and switchgrass that are to be used in the study. Cotton and sudangrass will be established each spring for the period of study. Two field replications, each consisting of 5 rows, 3 feet wide, 300 feet long will be used for each crop.

Effect of solar radiation, air temperature, and humidity on seed (or the production of seed) in some native and introduced grasses.

The micro-environmental conditions to which crops are subjected during bloom and dough stages to a large extent determine the yield and quality of the seed crop. Switch, bluepanic, brome and a number of other grasses are very sensitive to climatic conditions during seed development and maturity. The factors involved in the failure to set seed one year and a good set the next may be an interaction of humidity, hot dry-wind, high solar and nocturnal radiation, soil temperature, high conductivity of the seed appendages, etc.

Objectives: To measure the effect of solar radiation, air temperature, humidity and soil temperature on seed set of brome and switchgrass.

A horizontal canopy of 45° angled louvers (10' x 10') mounted on legs and built to allow free air movement for placement over the plants under field conditions prior to the bloom stage had to be made to conduct this study. The necessary materials have been gathered and will be set up this spring at the El Reno station.

Control of diseases in grasses grown for seed production.

Ergot and false-smut retard seed production of a number of grasses desirable for regrassing programs.

Objectives: To test the use of 2,4-D and some of the herbicides presently being used and tested as pre-emergence and post-emergence treatments, in controlling soil born diseases.

Extensive work on this problem will be initiated in 1960 on buffalograss using various rates of 2,4-D. Weather conditions this past summer prevented the study from being conducted during 1959.

Methods of measuring seed and forage yields.

Seed and forage yields were harvested by hand from all grass species under seed production studies. Two methods, differing in plot sizes and in procedure of handling and cleaning the seed, were used: (1) 1 x 3' plots and (2) 10 x 3' plots.

The study on methods of measuring seed yields was conducted on sideoats grama. The areas selected for study were being utilized for other studies: (1) tolerance of sideoats grama to selective herbicides, and (2) the effect of systemic and contact insecticides in controlling thrips and gall midges.

The yields reported below are an average of 3 yield-samples harvested in each plot and are reported in pounds of seed unadjusted and adjusted on the basis of purity per acre.

Mean square and F values of the interaction and sampling errors on harvested seed yields from the A.O.V. of the 1 x 3' and 10 x 3' plots of sideoats grama

Source	Unadjusted Yield		Percent Pure Seed		Yield Adjusted Common Purity Level	
	M.S.	F	M.S.	F	M.S.	F
(1st crop Insecticide study)						
<u>Plot size 1 x 3'</u>						
Replication x Treatments	12.19	.3362	40.25	.8112	1.14	.1756
Sampling Error	34.76		49.62		6.49	
<u>Plot size 10 x 3'</u>						
Replication x Treatment	16,803.17	4.95	141.02	7.458*	1,971.60	12.00*
Sampling Error	3,392.42		18.91		164.30	

(2nd crop Insecticide study)						
<u>Plot size 1 x 3'</u>						
Replication x Treatment	31.45	2.584	3.09	1.0729	9.51	3.944
Sampling Error	12.17		2.87		2.41	

(1st crop Herbicide study)						
<u>Plot size 1 x 3'</u>						
Replication x Treatments	9.92	2.111	131.83	1.3056	1.25	.1078
Sampling Error	46.99		100.97		11.61	
<u>Plot size 10 x 3'</u>						
Replication x Treatment	2,338.01	2.113	1.65	.67	319.21	1.8497
Sampling Error	1,107.36		2.47		172.57	

By examining the differences found in the size of the error terms, these tests, on harvest procedures in sideoats grama indicate that if yields are to be measured by harvesting a 1 x 3' plot, both the number of field replications will have to be increased.

The large error (replication x treatments) interaction measured by using the 10 x 3' plot for harvesting seed, indicates the number of plots taken per field treatment and replicate were adequate. However, to reduce this error there is a definite need to increase the number of field replications.

It is felt the present field designs and methods of measuring plot yields are not the best. Seed yields of chaffy-seeded grasses are more difficult to handle and measure yield uniformly as compared to other crops. The development of a quick test for determining the pure seed content should greatly accelerate any future work conducted on grass seed production. Adjusting total plot yields of varying purity levels to a common purity basis is essential if erroneous conclusions are to be omitted from seed production studies on chaffy seeded native and introduced grasses.

Similar studies are being conducted on Switchgrass, and lovegrass and buffalograss. The large interactions found with sideoats are also evident in these grasses. However, with buffalograss grown in a solid stand, the 1 x 1' quadrat and the forage chopper (8.7 x 5') gave the most consistent measurement of yield in comparison to the 10 x 3' plot cut with a Jari mower.

More intensive work is needed on methods of harvesting chaffy grass seed yields, but should be reduced to include only one or two grasses.

OREGON

Title: DEVELOPMENT AND TESTING OF EQUIPMENT FOR SEEDING GRASSES ON THE SAGEBRUSH-BUNCHGRASS RANGE

Leaders: Dean E. Booster, D. N. Hyder and F. A. Sneva.
Cooperating Agencies: Squaw Butte-Harney Branch Experiment Station, Agricultural Research Service, and the Department of Agricultural Engineering

Objectives: 1. To design, construct, and test seeding equipment which will firm the soil in strips or furrows and plant the seed at a uniform and proper depth in the center of the pressed furrows with firm soil below and less-firm soil above the seed.

Progress: A 12-row seeder, Desert Flower IV, was constructed and used for field seeding work in 1959 by the Bureau of Land Management, U. S. Department of Interior, in Oregon and in Nevada.

The 8-row seeder, Desert Flower III, was used by ranchers and government agencies in the Burns, Oregon area and improvements have been made in it.

Preliminary development phases of the "Oregon Press Seeder" have been completed. Plans and specifications for Desert Flower IV have been prepared and are available. Further development of this seeder will be under the direction of the Interagency Range Seeding Equipment Committee.

Title: DEVELOPMENT OF IMPROVED METHODS OF PLANT IDENTIFICATION

Leaders: LaRea J. Dennis and Helen M. Gilkey

Objectives: 1. To facilitate the identification of seedling and immature stages of weeds, browse plants, forbs, and common grasses of Oregon.

Progress: Seedlings and immature plants of over 100 species of weeds have been grown out in the greenhouse and in field plots. From these a tentative key to seedlings and immature plants of over 50 species common to western Oregon has been prepared.

Work is continuing and additional keys for eastern Oregon are planned.

Title: SELECTIVE AND NON-SELECTIVE WEED CONTROL ON AGRONOMIC CROPS AND NON-CROP LAND AND FACTORS AFFECTING CONTROL PRACTICES

Leaders: W. R. Furtick, W. O. Lee, F. E. Phipps, and A. P. Appleby.
Cooperating with Oregon Branch Experiment Stations.

Objectives: 1. Develop experimental techniques for evaluation of herbicides under greenhouse and field conditions.

2. Develop controls for weeds by chemical or combination chemical-cultural and cropping methods.

3. Develop procedures for the control of vegetation on non-crop areas.

4. Study factors which might influence weed control measures.

5. Develop weed control measures for the state in cooperation with branch stations.

Progress: New herbicides from the chemical industry were evaluated on crop and weed species, including range weeds. Several new chemicals were found promising.

Chemical control of Bromus tectorum in cereals is contributing valuable information on control of this and other annual grasses.

October applications of neburon, simazin, and atrazine on spring-seeded grasses showed promise for selective control of winter annual weeds.

Work has been done on the control of Chrysanthamnus nauseosus and C. viscidiflorus. New work is contemplated on Artemisia tridentata, Chrysanthamnus spp., and Elymus caput-medusae.

Title: DEVELOPING IMPROVEMENT AND MANAGEMENT PRACTICES FOR SEMI-ARID RANGE AND FOOTHILL PASTURES

Leaders: D. W. Hedrick, C. E. Conrad, and C. E. Poulton.
Cooperating Agencies: Squaw Butte-Harney Range Experiment Station, Agricultural Research Service; Forest Service; Bureau of Land Management, U. S. Department of Interior; Union Branch Experiment Station and the Departments of Soils, Farm Crops, Agricultural Economics and Botany.

Objectives: 1. Conduct clipping and grazing trials to determine the relative seasonal productivity and nutritive value of several native and recommended species and mixtures used for dryland pastures on foothill areas in Oregon.

2. Test seeding mixtures for rapid establishment, competitive ability with undesirable species and for ease of maintenance under recommended management practices.

3. Develop fertilizer recommendations for use on range seedings that will aid in establishment, maintenance and productivity of the stands under grazing management.

Western Oregon - Specific Objectives:

1. Evaluate interactions between fertilizer and simulated grazing practices (clipping) on grass-legume stands used for dryland pasture on foothill lands in western Oregon.

2. Develop control measures for brush species in conjunction with grazing management on marginal foothill ranges lying between valley and forested areas.

Eastern Oregon - Specific Objectives:

1. Study ecological response of sagebrush range to improvement practices and evaluate methods used.

2. Establish grazing trials to evaluate the influence of timing and intensity of grazing on certain grass stands in eastern Oregon subject to rapid invasion of undesirable shrubs.

Progress: Work under this project is being conducted in five study plans. The third and next to last annual clipping has been completed on a fertilizer-clipping interaction study on improved foothill pasture. Changes in composition as well as yield are being followed.

The effect of different grazing management programs on the ability of alfalfa-grass mixtures to resist reinvasion of sagebrush is being conducted.

A methods comparison study is near completion for determining vegetation succession following sagebrush removal by spraying and rotobating. This study is also providing a measure of succession on fair and poor condition range.

Initial preparation was made for a study of the compatibility of subterranean clover and various companion species and for a comparison of common-use grazing on western Oregon foothill lands.

Title: PLACE OF FORESTRY, GRAZING OR JOINT USE ON FOOTHILL LANDS IN OREGON

Leaders: D. W. Hedrick, R. F. Keniston, J. A. B. McArthur, C. E. Conrad, and C. E. Poulton.

Cooperating Agencies: Union Branch Experiment Station, Range Management Program and Forest Research Division of the Oregon Agricultural Experiment Station

Objectives: 1. Obtain physical and economic data on the best use of marginal foothill lands in both western and eastern Oregon--whether for farm forestry, grazing, or both.

2. Study the effects of oak removal and of grazing, both by sheep and deer, on the establishment and growth of Douglas-fir plantations in the foothill lands of western Oregon.

3. Determine the economic factors affecting forest management decisions in small ownerships in western Oregon.

4. Test establishment and growth of ponderosa pine ecotypes on representative ecological sites in the foothills of the Blue Mountains in eastern Oregon.

5. Conduct common-use grazing trials with cattle and sheep on forested foothill ranges in the Blue Mountains.

Progress: Pasture production, Douglas-fir browsing damage by sheep and by deer, and tree growth rates plus soil moisture depletion rates are being studied under a five treatment experiment comparing straight pasture with planted Douglas-fir under thinned, clearcut and normal stands of Oregon white oak. Forage yield records are being obtained in terms of animal gain.

Random samples of small-forest owners, for the decision-factor study, were drawn in four counties in western Oregon. Interviews were conducted to learn how personal as well as economic factors affect the decisions.

Ponderosa pine seedlings from seed collected from five ecological sites in the Blue Mountains and from the State Nursery stock were grown through their first year in nurseries at the Union Station and in the State Forest Nursery in Corvallis. These seedlings will be used in reciprocal plantings on five ecological sites on the Hall Ranch, Union Branch Station, in the Blue Mountains.

Title: IMPROVEMENT OF SOUTHEASTERN OREGON RANGES THROUGH RESEEDING AND MANAGEMENT

Leaders: D. N. Hyder and F. A. Sneva.
Cooperating Agencies: Range Management Program and Department of Farm Crops. Project under Agricultural Research Service leadership.

Objectives: 1. Adaptability and performance of selected introduced grasses and legumes as related to weather conditions, clipping and grazing treatments, fertilizer applications, and site quality.

2. Seasons, methods, and equipment for establishing desirable forage species.

3. Physiological responses of forage plants as influenced by clipping or grazing treatments, fertilizer applications, stand density, site quality, and weather conditions. Physiological responses as related to root and stem morphology and phenological sequences in vegetative and reproductive activities

4. Range production as related to precipitation and temperature fluctuations from year to year.

5. Palatability and quality of various forage species as related to seasonal development, stand density, fertilization, and chemical content.

Progress: Investigations under this project are being conducted under 12 Agricultural Research Service Field Plans. It is assumed that detailed reporting as desirable will be handled by the Agricultural Research Service.

Title: RANGE IMPROVEMENT IN SOUTHEASTERN OREGON THROUGH CONTROL OF UNDESIRABLE PLANTS

Leaders: D. N. Hyder and F. A. Sneva.
Cooperating Agencies: Range Management Program and Department of Farm Crops. Project under Agricultural Research Service leadership.

Objectives: 1. Develop improved recommendations for the chemical control of big sagebrush, low sagebrush, green rabbitbrush, gray rabbitbrush, low larkspur, death camas, and other undesirable range plants.

2. Evaluate ecological and economic responses to weed control practices.

3. Evaluate cultural and management practices pertinent in the ecological control of undesirable range plants.

Progress: These investigations are being carried out under five Agricultural Research Service Field Plans.

Title: DESCRIPTION, CLASSIFICATION AND CORRELATION OF OREGON SOILS

Leader: Ellis G. Knox.
Cooperating with Soil Conservation Service.

Objectives: 1. To provide named taxonomic classes (soil series and classes at other categorical levels) within the nationally recognized system of soil classification.

2. To derive from the taxonomic classes (ordinarily soil series) map units suitable for soil surveys, both detailed and generalized.

3. To make technical, interpretive groupings or classifications for special purposes.

Progress: Joint work with the Soil Conservation Service includes substantial amounts of work on the soils of range land.

A soil map of the state was prepared as a part of a map of the 11 western states.

Title: DETERMINE BEST USE AND IMPROVEMENT PRACTICES FOR FOOTHILL RANGES, BOTH OPEN AND FORESTED, IN NORTHEASTERN OREGON

Leaders: J. A. B. McArthur, D. W. Hedrick, J. E. Oldfield,
R. F. Keniston, R. G. Peterson, and R. L. Walton

Objectives: 1. Conduct nursery clipping and grazing trials to determine the relative seasonal productivity and nutritive value of several recommended species and mixtures for seeding dryland pastures in Eastern Oregon.

2. Test seeding mixtures for use in Eastern Oregon for rapid establishment, competitive ability with undesirable species, and for ease of maintenance under recommended management practices.

3. Develop fertilizer recommendations for use on range seedings that will aid in establishment, maintenance and productivity of the stands under recommended grazing management.

4. Establish grazing trials (common use) to evaluate the influence of grazing on certain stands in eastern Oregon.

5. Collect data on wildlife utilization of native and reseeded stands in Eastern Oregon.

6. Determine seasonal variation among native forages for composition, yield and nutrient content in typical forest-range sites in the Blue Mountain area of Northeastern Oregon.

Progress: 1. Objectives 1, 2, and 3 are being investigated in a grass-legume nursery seeded to 13 species or species combinations. Yield and chemical composition are being studied at four growth stages with and without fertilizer. The species are being tested for dry mountain meadow seeding in the ponderosa pine zone. The test includes Whitmar beardless wheatgrass, intermediate wheatgrass, crested wheatgrass, pubescent wheatgrass, creeping meadow foxtail, hard fescue, timothy, Sherman big bluegrass, tall wheatgrass and Granger lotus, intermediate wheatgrass and Nomad alfalfa, Whitmar beardless wheatgrass and hard fescue, and crested wheatgrass and hard fescue.

2. Under Objective 6 the seasonal yield and chemical composition of native species is being studied on three sites, Ponderosa pine-Douglas fir-Pinegrass, Dry Mountain Meadow, and Mixed Fir Forest. To date the first named type has been the most productive for livestock grazing.

Title: ECONOMICS OF RANGE RESOURCE DEVELOPMENT THROUGH RANGE RESEEDING

Leader: C. V. Plath

Cooperating Agencies: Range Management Program; Bureau of Land Management, U. S. Department of Interior; Forest Service, U.S.D.A.

Objectives: 1. On private lands: An economic appraisal of the benefits derived from range improvement practices used on deeded land as part of operating cattle ranches during 1953-1960.

2. On public lands: An economic analysis of the costs and returns of range reseeding on federal rangeland seeded by public agencies in 1952-1954.

3. Obtain supplemental data on ranch organization and operations, and on reseeding.

Progress: Essentially all the field data are gathered for this project but analyses are incomplete.

Title: IMPROVEMENT OF RANGE LIVESTOCK PRODUCTION ON THE OREGON HIGH DESERT AREA THROUGH NUTRITION AND MANAGEMENT RESEARCH

Leaders: Robert J. Raleigh, Joe D. Wallace, W. A. Sawyer, and W. P. Skelton
Cooperating with Crops Research Division, Agricultural Research Service

Objectives: 1. To evaluate the nutritive quality of range and meadow forage through the use of chemical determination, in vitro methods utilizing rumen bacteria, apparent digestion studies, and animal performance.

2. To relate the nutrient composition of the diet of various classes of range beef cattle on grass and meadow forage rations to known animal requirements.

3. Provide nutrient supplements to meet deficiencies in the diet and study animal response in terms of rate of gain, calf production, blood composition, and liver storage of nutrients.

4. Study the influence of the addition of non-nutrient supplements on animal performance where it seems likely that a positive response will be obtained.

5. Determine the influence of various management practices on animal performance through the analysis of production data collected on the Squaw Butte Station herd of beef cattle.

6. Assemble the research findings into recommendations of practical use in the conversion of range and meadow forage to meat.

Progress: Three study plans are concerned with mineral nutrition, phosphorus, copper, cobalt and iron.

One study plan is considering the effect on yearling steers of energy, protein, and sodium supplements while grazing on crested wheatgrass.

Another investigation is on the use of repellents to control or influence cattle grazing on the range. Three compounds have been tested. One compound, Chipman's No. 6048 was reasonably effective, after initial exposure and in high rates of application, in preventing cattle from consuming forage.

Title: TESTING OF NATIVE, INTRODUCED AND IMPROVED SPECIES OF GRASSES
AND OTHER GENERA FOR PRODUCTION OF FORAGE AND SEED AND OTHER
UTILITY

Leader: H. A. Schoth.
Cooperating with Agricultural Research Service, Crops
Research Division.

Objectives: 1. To evaluate and determine by observation and recorded data the following: a. Adaptation to environmental conditions. b. Hardiness, especially winter. c. Length of life. d. Comparative values of various species within a genus. e. Comparative values of strains within a species. f. Insect and disease resistance or susceptibility. g. Determine possibilities of semi-noxious or noxious status. h. Determine capabilities of forage and seed production. i. Potential improvement possibilities. j. Determine seasonal growth. k. Note any specific or outstanding qualities.

2. Determine and record botanical characteristics.

3. Testing of 59 subterranean clover hybrids of Australian origin to determine: a. Adaptability. b. Productivity--forage and seed.

Progress: In addition to subterranean clover, work was concentrated on Tualatin tall oatgrass, orchardgrass, Festuca elatior arundinacea, and Phalaris tuberosa.

Numerous strains, types and varieties of grasses, legumes and other plant classes were eliminated from tests because of negative values.

SOUTH DAKOTA

Title: MINERAL REQUIREMENTS AND MINERAL SUPPLEMENTS FOR GROWING-FATTENING CATTLE

Leaders: L. B. Embry, A. E. Dittman, G. F. Gastler and O. E. Olson

Objectives: 1. To determine the mineral requirements for growing-fattening cattle.

Progress: Work was completed and published during the past year on tolerance of salt in water for cattle. Work was initiated on the need for cobalt supplementation on native range. Cattle pastured on native pasture and fed prairie hay in the Eureka area gained about 8-14% more when given a 20 gm. cobalt bullet than similar animals not given cobalt. This response was obtained with and without stilbestrol implants which gave a 11% increase in gain. The cattle are being fattened and determine the effect of the stilbestrol implant on feed lot gains when all cattle receive stilbestrol in the feed. Suckling lambs on range but having access to creep feed have shown only slight responses to cobalt. The cobalt trials indicate that native prairie ranges in South Dakota may be low in cobalt and animals grazing them need cobalt supplementation. The study will have to be made on a larger scale before this can be established.

Title: PROTEIN AND ENERGY REQUIREMENTS OF BEEF CATTLE

Leaders: L. B. Embry, F. W. Whetzal, W. B. McGillick, D. H. Reid, M. A. Hoelscher, L. D. Kamstra and R. J. Emerick

Objectives: To determine the protein and energy requirements and interrelationships of beef cattle at various levels of production.

To determine the effect of various protein and energy intakes on subsequent performances by beef cattle and the effects on carcass quality and composition.

Progress: Wintering trials with calves showed gains again increased as protein level of all-hay rations increased from about 8-12 per cent by feeding different amounts of alfalfa and prairie hay. Similar results have been obtained but with higher rates of gain when calves were fed limited grain rations. High protein levels improved efficiency of gains but increased total winter feed costs. Reducing feed intake on a high protein ration reduced gain and increased feed per unit of gain but reduced winter feed costs. It was more

restricting protein level in the ration. Calves from the wintering trials the previous year gained over two pounds per head daily during the summer on low-moisture alfalfa-brome silage. Calves wintered to gain up to one pound daily gained as well as those wintered for lower gains. In fattening trials, gain increased as roughage of ration was reduced from 50 to 35 to 20 per cent. Improvement in feed efficiency was more pronounced in rate of gain. Stilbestrol gave improvement in rate of gain with all levels of roughage. Dynafac appeared to be beneficial only with the 20 per cent roughage rations. Diallylstilbestrol and Agrozyme did not give a response. Lamb fattening trials have shown that high grain rations give good gains with rather low feed requirements per pound of gain. Stilbestrol gave a good response with implants being more effective than in the feed. Dynafac appears to be of some value with high grain rations. Results of wintering trials show that level of wintering should depend on feed supplies and subsequent feeding system. Wintering trials show protein levels and feed requirements necessary to obtain various rates of gain. Fattening trials show gain and feed efficiency with different amounts of grain and roughage. These form basis for selecting rations depending on feed costs and market conditions. Stilbestrol is an economical feed additive and type of ration does not appear to affect the response. Dynafac may prove economical with high grain rations.

Title: FEEDING VALUE AND DIGESTIBILITY OF GRASSES AND HAYS OF THE
NORTHERN GREAT PLAINS

Leaders: L. B. Embry, F. W. Whetzal, A. L. Musson, G. F. Gastler and
O. E. Olson

Objectives: To obtain data on the composition, digestibility and productive value of pastures and hays.

1. To determine by feeding trials, digestion, and where necessary, metabolism trials conducted simultaneously, the nutritive value of grasses cut for hay and stored at shooting stage, seed ripe stage, and mature stage. This will be done on hay cut at different locations within the state--Cottonwood, Eureka and/or Highmore, Brookings, Reed's Ranch, and Antelope Ranch--which represent different conditions as to soil, weather and grass species.

2. To store sufficient hay by stacking or other methods such as baling at Highmore and/or Eureka, Cottonwood, and Antelope Range that a feeding trial and/or digestion trial can be conducted each year for five years on hay stored one year, two years, three years, four years, and five years. This phase is aimed at stabilizing feed supplied and livestock production by storing feed grown in good feed production years to provide adequate feed in dry years.

3. To conduct digestion trials with steers on pasture and in dry lot from grass cut from similar pastures throughout the year at approximate bi-monthly periods at Cottonwood. This phase will be done during the summer at Brookings. This is to determine the composition and digestibility of feed as the animal uses it on the range or in the pasture.

4. To formulate a livestock program from the information known and gained in 1, 2, and 3 as to digestibility, feeding value, protein, minerals, quality of forage, time of making maximum use of pastures and hays, supplements needed, etc., which takes maximum advantage of what feed the rancher or farmer has at hand in developing a larger and more efficient livestock production.

5. To find a simpler method for determining digestibility of growing pasture grass and feeds using steers that will reduce the cost, time, labor involved, etc. This will be a by-product of the above work but can be of great value to the livestock industry.

Progress: Winter feeding trials using steer calves fed prairie hay stored in open stacks has shown that best gains are generally obtained when fed hay harvested the previous season. Hay from well-made stacks of loose hay has given better and more consistent gains from year-to-year than stacks of baled hay. Well-made stacks also have had less rotten and damaged hay after more than one year in storage. Method of storage, baled or loose, does not seem to influence feeding value or storage during storage for only one winter. Gains from hay fed from 1 to 6 years following harvest and storage have been quite variable indicating animal and environmental differences between years. The project is designed so annual trends for hay harvested during five different years can be studied.

Title: LEVELS AND LENGTHS OF TIME OF CONCENTRATE FEEDING FOR WINTERING BRED RANGE EWES UNDER RANGE CONDITIONS

Leaders: J. K. Lewis, F. R. Gartner, L. B. Embry and W. R. Trevillyan

Objectives: 1. To compare feeds containing different levels of protein as supplements to bred ewes winter-grazed on the range with respect to maximum net returns from lamb and wool.

2. To compare the feeding of different amounts of protein supplement to bred ewes winter-grazed on the range.

3. To compare supplemental feeding of winter-grazed range ewes during the entire winter season with supplemental feeding during only a part of the season.

Progress: Ewes winter grazed on deferred range in excellent condition have been fed the following protein supplements daily: (1) 1/3 pound 40% winterlong (November 1 to lambing); (2) 1/3 pound 20% winterlong; (3) 1/3 pound 40% last 6 weeks of gestation, or (4) 2/3 pound 20% winterlong. One hundred ewes were permanently allotted to each winter supplemented lot and to each summer grazing treatment (project 177) in 1952, so that winter and summer treatments were balanced in each lot. Replacements have been chosen from the lots in which they were produced. In 1959 grease fleece weights were 9.9, 9.8, 8.9 and 10.3 pounds; lamb crop born were 128.0, 106.8, 110.0 and 129.3 percent; lamb crops weaned were 108.0, 91.9, 90.0 and 108.0 percent; weaning weights of single lambs were 85.9, 82.6, 82.5 and 88.5 pounds; weaning weights

of twin lambs were 68.7, 72.5, 64.2 and 70.8 pounds; lamb weights weaned per ewe bred were 84.1, 74.1, 73.4 and 84.8 pounds for lots 1, 2, 3, and 4, respectively. Response to winter supplemental feeding is strongly conditioned by summer grazing intensity. Year to year variations have been large.

Title: THE CUMULATIVE EFFECTS OF VARIOUS SUMMER GRAZING TREATMENTS ON RANGE EWE PRODUCTION AND ON THE NATIVE VEGETATION IN NORTHWESTERN SOUTH DAKOTA

Leaders: J. K. Lewis, F. R. Gartner, L. B. Embry and W. R. Trevillyan

Objectives: 1. To compare the progressive effects of different rates of grazing on summer range with respect to the maximum ewe, lamb and wool production.

2. To determine and compare the progressive effects of different rates of grazing on Mixed Prairie type vegetation in northwestern South Dakota, and to determine the optimum carrying capacity of sheep ranges on the western South Dakota ranges.

3. To compare and determine the progressive effects of different rates of grazing on the soils of northwestern South Dakota.

4. To compare a moderately grazed rotational deferrment system with continuous seasonlong grazing with respect to ewe, lamb and wool production and the progressive effects on the vegetation and soils.

5. To determine the effects of a flushing treatment prior to breeding in the fall on range ewe production the following year.

Progress: An intensity of grazing study with sheep has been conducted at Antelope Range from about May 1 to November 1 each year since 1950. One hundred ewes were permanently allotted to each grazing treatment and to each winter feeding treatment in 1952, so that winter and summer treatments were balanced in each lot. Replacements have been chosen from the lots in which they were produced. In 1959 stocking rates were 0.87, 0.68 and 0.42 acres per ewe month, lamb crops born were 126.0, 117.1 and 112.0 per cent; lamb crops weaned were 103.0, 91.3 and 104.0 per cent; weaning weights of single lambs were 86.8, 85.2 and 83.4 pounds; weaning weights of twin lambs were 72.3, 67.6 and 69.1 pounds; lamb weights weaned per ewe bred were 83.8, 72.8 and 80.7 pounds, respectively, for heavy, moderate, and light grazing. Summer grazing response is strongly conditioned by winter plane of nutrition. Year to year variation has been large.

Title: SUMMER GRAZING OF BEEF COWS FOR CALF PRODUCTION

Leaders: J. K. Lewis, F. R. Gartner, O. E. Olson and Donald Woodford

Objectives: 1. To continue to study the cumulative effect of different intensities of grazing on forage production and on cow and calf production.

2. To study the effect of different intensities of grazing on the effectiveness of precipitation.

3. To accumulate information concerning the approximate species composition (relative coverage) of the range which will give maximum sustained livestock production.

Progress: Six pastures at the Cottonwood Range Field Station have been grazed heavily, moderately or lightly from about May 1 to December 1 each year since 1942. Yearling grade Hereford heifers were permanently allotted to different grazing treatments in the fall of 1952 and were sold in the fall of 1959 after producing six calf crops. These studies have shown that cow weight gain, fall condition of cows, birth weight, weaning weight and condition of calves, as well as range condition and forage production, are highest under light grazing, lowest under heavy and intermediate under moderate grazing.

Title: SOCIAL AND ECONOMIC FACTORS ASSOCIATED WITH SUCCESS OR FAILURE OF FARM AND RANCH OPERATIONS ON INDIAN RESERVATIONS IN SOUTH DAKOTA

Leaders: V. D. Malan, A. R. Clark and E. L. Schusky

Objectives: 1. To investigate the farm management aspects of personal and social factors peculiar to Indian culture.

2. To identify those factors which are most likely to contribute to the success or failure of the farm or ranch business enterprise.

3. To make recommendations for remedying factors associated with failure.

4. To make recommendations as to desirable size of operation for Indian families.

5. To investigate social factors which are influential in the adjustment of the Indian families on the Crow Creek and Cheyenne River Reservations.

6. To make recommendations for progress designed to improve the level of adjustment of the Indian families on these reservations.

Progress: A research design was completed and questionnaire written. Ranches on the Pine Ridge Reservation will be interviewed and compared to a non-ranching group. The interviewing is currently underway and will be completed in a few months.

TEXAS

Title: THE RANCH CREDIT SITUATION IN TEXAS DURING THE 1950-57 DROUTH AND THE EARLY RECOVERY PERIOD

Leader: Harley Bebout, Department of Agricultural Economics and Sociology

Nature of

Research: Project is designed to determine how financial losses sustained due to the 50-57 drouth affected the financial and credit position of ranchers to continue operations during the drouth and their ability to obtain necessary credit for restocking and other purposes during the post drouth recovery period. Loan data is obtained from lending agencies serving ranch areas.

Progress: The financial position of ranchers deteriorated most rapidly during the early years of drouth, particularly for lease operators; land value rose in spite of the drouth. Income from minerals and outside employment were important non-ranching sources of income and enabled many to stay in business. Forced liquidation was negligible and credit was available for those desiring to continue operations although many had to resort to emergency government loans. Emergency programs enabled retention of basic livestock herds. Recovery has been rapid and with ample credit available ranches are again fully restocked. Ranchers generally are further in debt, but with three successive good years, they are in good positions to repay.

Title: THE CHEMISTRY OF THE POISONOUS RANGE PLANTS OF TEXAS

Leaders: Bennie J. Camp, Department of Biochemistry and Nutrition. Cooperating with J. W. Dollahite, Animal Disease Investigations Laboratory, Marfa, Texas; Charles Livingston, Ranch Experiment Station; Ted Shaver, Department of Biochemistry and Nutrition; and Charles Bridges, Department of Veterinary Pathology and Robert Pigeon, Department of Biochemistry and Nutrition

Nature of Research: This program entails the isolation and characterization of the poisonous principle of the more economic important range plants of Texas. This study also includes the pharmacological properties of the isolated principles. The ultimate objective of this program is to find some means of neutralizing the toxic effect these compounds have on range animals.

Progress: A sympathomimetic amine has been isolated from Acacia berlandieri. A method has been devised for the large scale synthesis of the amine which will permit toxicological studies on range animals. An analytical procedure has been developed for assaying the amine content of guajillo.

Title: CONTROL OF NOXIOUS BRUSH ON TEXAS RANGELANDS

Leaders: R. A. Darrow and W. G. McCully, Department of Range and Forestry. Cooperating with E. E. Hughes and E. D. Robison, Spur Substation; H. L. Morton, Agricultural Research Service and T. H. Silker, Texas Forest Service

Nature of Research: Evaluation of effective and practical methods for control of major types of brush on range lands of Texas with emphasis on mesquite, sand shinnery oak, post and blackjack oaks, whitebrush (Aloysia lycioides), Macartney rose and undesirable hardwoods in pine-hardwood types. Emphasis has been placed on the use of chemical control measures; effects of brush control on forage and livestock production and on physiological studies of the response of woody plants to herbicides under controlled conditions.

Progress: New recommendations have been made for the control of (1) sand shinnery oak, two yearly applications of 2,4,5-T or silvex at 0.5 lb/A in 4 gallons of emulsion; (2) whitebrush, aerial application of 1-1/4 lb/A of MCPA amine in 8 gallons of emulsion; (3) post-blackjack oaks, basal application of 1-2 tbls. of fenuron pellets per stem during winter or spring months.

Invert emulsions of 2,4,5-T gave comparable results to standard emulsions in the control of mesquite, oak and other brush. Macartney rose has been controlled by repeat foliage spray applications of 2,4-D ester or amine; granular applications of 2, 3, 6-TBA also show favorable response.

Comparisons were made of fixed wing and helicopter applications of herbicides for pine release in pine hardwood stands. Studies were initiated on the effects of rootplowing and aerial spraying of mesquite on climatic and edaphic factors of the site.

Studies were made in controlled-environment chambers of the effects of various temperatures and humidities on the response of mesquite to herbicide applications and on the chemical composition of brush seedlings. Methods were developed for propagating of mesquite, live oak, whitebrush and retama for laboratory studies with herbicides.

Title: EFFECT OF FERTILIZER TREATMENTS ON RANGE FORAGE PRODUCTION AND VEGETATIONAL COMPOSITION

Leaders: R. A. Darrow, Department of Range and Forestry; Judd Morrow, formerly Department of Range and Forestry; A. G. Caldwell, Department of Agronomy and W. J. McBride, Encino Field Laboratory, Cooperative with King Ranch, Inc., and Monsanto Chemical Company

Nature of Research: An evaluation of the effects of N, P, and K applied in a 2 x 3 x 3 factorial experiment on the forage yields and vegetal composition in ungrazed areas in the Coastal Prairie in Brooks County, Texas. Effects of aerial fertilization applications of combinations of P, K, and N on grazed pastures were also observed.

Progress: Forage yields and botanical composition data were obtained in November - December, 1959 from 14 ungrazed exclosures after fertilizer applications in March, 1956 on replicate 10 x 90' plots as follows: N-0, 30; P₂O₅-0, 60, 120; K₂O-0, 40, 80 lbs/A. Preliminary evaluation of yield data shows no significant increase in total forage due to fertilizer. Single additions of 40 lbs. K₂O and 60 lbs P₂O₅ per acre gave a 25-29% increase in yield of desirable grasses such as seacosst bluestem and brownseed paspalum compared to 733 lbs/A on untreated plots. Total herbage production averaged 2879 lbs/A on untreated plots.

Applications of N with P or K tended to reduce total herbage production 3 years after treatment. Addition of P reduced the yield of desirable grasses and favored growth of the less desirable Brachiaria ciliatissima on both grazed and ungrazed areas.

Title: THE EFFECTS OF BRUSH CONTROL ON WILDLIFE IN THE RIO GRANDE PLAINS

Leaders: Richard B. Davis, Robert L. Spicer and Jack M. Inglis, Department of Wildlife Management

Nature of Research: The ultimate objective of this project is to determine the resource value which should be assigned to wildlife in the planned, conservative manipulation of rangelands for sustained highest yields of all useful products.

Game species of wildlife, an increasingly marketable and profitable range-lands resource, apparently depend on the presence of appreciable amounts of forbs and woody plants. These same plants are often considered detrimental to efficient production of domestic livestock. The conflict of economic interests posed by this apparent conflict between the ecological needs of two useful range products has revealed a basic controversy regarding the character and potential productiveness of rangelands.

There has been an awakening to the need for unified principles for range research and management, and a realization that unified principles can come only from research based on unified experimental designs. To study range-lands properly, it has become obvious that the disciplines of soil science, microbiology, plant physiology, hydrology and entomology must be called upon and their efforts joined with those of wildlife and range ecology in the simultaneous study of experimental ranges.

The Texas Game and Fish Commission, through participation in the Federal Pittman-Robertson program, has taken the lead in Texas in establishing a unified experimental project. TAES Project 1203, under the title of this report, is financed by contract between the Texas Agricultural Experiment Station and the Texas Game Commission. Funds made available, however, are to be used only for research on vertebrate wildlife, review of general aspects of history and present status of habitat, and for the salary of a project coordinator. Financial responsibility for studies by associated disciplines is left to other agencies.

Progress: To date a report of the extent and kinds of brush control is nearing completion; a review of history of wildlife and habitat in the Rio Grande Plains is half completed; preliminary proposals by representatives of the Texas A. and M. College Departments of Range Management, Entomology, Biology and Agronomy have been developed as integral parts of a single study of the effect of brush control on rangeland; and a survey is beginning on the food habits of white-tailed deer throughout the Rio Grande Plains.

Commencement of the simultaneous studies of a single tract of rangeland, including a thorough, year-long inventory of conditions before brush control, immediate responses to control of brush, and continuing inventory of re-adjustment of the range toward a new equilibrium, depends upon allocation of additional funds for support of studies other than vertebrate wildlife and for consignment of an area committed to research on these long term problems.

Title: BIOLOGY AND CONTROL OF RHODES-GRASS SCALE, ANTONINA GRAMINIS
(MASKELL)

Leaders: H. A. Dean and Michael F. Schuster, Entomology at Substation
No. 15, Weslaco, Texas

Nature of Research: Rhodes-grass scale cannot be controlled economically on pasture grasses with chemicals. The employment of beneficial insects is the best approach to a solution to the problem along with the replanting of Rhodes grass with more tolerant strains of this grass to the scale insect.

Progress: Biological control: An Encyrtid parasite, Dusmetia sangwani Rao, was introduced from New Dehli, India during the spring of 1960. The parasite was distributed from laboratory culture. Recovery has been made in the dry-land area of the Rio Grande Valley and on King Ranch. A report of the establishment of the parasite, Anagyrus antoninae Timb. on the scale in Mexico will soon be in press. Tolerant strains of Rhodes grass: Mass selection source nursery testing yielded several promising phenotypes which at present are in the second-cycle source nursery and testing program.

Title: PREVENTION AND CONTROL OF ABORTIONS IN GRAZING CATTLE
CAUSED BY EATING PERENNIAL GUTIERREZIA SPECIES

Leaders: J. W. Dollahite, Animal Disease Inv., Substation, Marfa, Texas
T. J. Allen; B. J. Camp, Department of Biochemistry and
Nutrition

Nature of Research: Efforts are being made to determine the chemical structure of the toxic principle in Gutierrezia species, and to determine which species of Gutierrezia are responsible for abortions. Work is underway to determine practical methods of control of Gutierrezia species.

Progress: A substance has been isolated from broomweed which induces abortion in pregnant rabbits. Work is in progress to purify and characterize the compound.

KURON: MCP: 2,4-D; and 2,4,5-T will control perennial Gutierrezia species.

Higher percentage of control was obtained in the spring when the soil moisture was above 1%, and when the soil temperature was between 60 and 80°F.

Title: THE RELATIONSHIPS BETWEEN RAINFALL AND THE FORAGE PRODUCTION
OF BLUE GRAMA GRASS

Leaders: George F. Ellis, Jr. Cooperating with Jack J. Bond and
Oliver R. Lehman, Agricultural Research Service

Nature of Research: The basic objective of the project is to obtain specific information on the relationships between rainfall, soil moisture, and forage production of blue grama grass on the High Plains of Texas.

Progress: In 1958, blue grama grass produced roughly 75 pounds of oven dry forage per acre inch of evapotranspiration. This is very inefficient water use as compared to dryland wheat and grain sorghum, which ordinarily produce from 300 to 400 pounds of oven dry material per acre inch of evapotranspiration.

In 1959, wide differences in soil moisture established at the beginning of the growing season failed to result in consistent differences in subsequent forage production. The fact that the high moisture level plots had some available moisture in the profile throughout suggests that something other than shortage of water may have been the limiting factor.

Title: DEVELOPMENT OF PRACTICES TO INCREASE THE PRODUCTION OF
NATIVE BUFFALO AND TOBOSA GRASS PASTURES

Leaders: C. E. Fisher, Substation No. 8; P. T. Marion, Substation No. 7;
Earl Burnett, Big Spring Field Station. Cooperating with
J. H. Jones, Department of Animal Husbandry.

Nature of Research: Production on upland buffalo-tobosa pastures averaged only 27 pounds per acre during a 10-year study 1942-1952. Methods such as supplemental feeding of cottonseed cake, spraying dry grass with molasses, mowing, weed control, application of manure and litter, contour furrowing and pitting were used to increase production.

Progress: Cottonseed cake fed throughout the grazing season on tobosa grass increased gains, but the value of the additional gain did not pay the cost of the cake. It was profitable to feed cottonseed cake during dry periods from July 15 to October 15 on upland buffalo-tobosa pastures. Molasses sprayed on dry tobosa grass increased its palatability and steers were able to remain on pasture without loss of weight.

Contour furrowing increased moisture penetration 24 to 36 inches on moderately sloping terrain. Tall grasses, mostly silver bluestem, invaded these sites. During the extreme drouth periods from 1953 to 1956, the pits and furrows maintained a good cover and provided the only edible forage on these sites.

Manure and litter from silos and cotton burs increased the penetration of moisture and the production of air dry buffalo grass was doubled.

Pastures sprayed with 2,4-D in the spring when moisture conditions were favorable for the growth of grass and weeds was a profitable practice. Sunflowers, annual broom weeds and thistles were effectively controlled and grass production was increased.

Title: THE REPRODUCTIVE CHARACTERISTICS OF ECOTYPE SELECTIONS OF ANDROPOGON BARBINODIS, A. SACCHAROIDES, AND BOUTELOUA CURTIPENDULA AS RELATED TO THEIR POTENTIAL USE IN REVEGETATION OF DEPLETED RANGE AREAS

Leaders: Frank W. Gould, Department of Range and Forestry, R. G. Reeves, Department of Genetics, E. C. Holt, Department of Agronomy, Zarir Kapadia, Department of Range and Forestry. Cooperating with W. H. P. Emery, Collaborator, Southwest Texas State College

Nature of Research: This project was set up with the following objectives: 1. To determine the regularity of macro and microsporogeneses and the incidence of cross and self fertilization, cleistogamy and apomixis in desirable ecotypes; 2. To determine if a correlation exists between chromosomal characteristics and physiological and morphological characteristics; 3. To determine the flowering and seeding characteristics of selected ecotypes as related to plant improvement and effective methods and techniques of seed production. Research on the Andropogon species has been completed and is reported on in publication. Studies of Bouteloua curtipendula, supported by a grant from the National Science Foundation, are now in progress. Principle objectives for 1959 were to "size up" the variability of B. cu in Texas and northern Mexico, to determine the best methods of sampling for morphological material and cytological variation, and to collect live clones, seeds, cytological material, and herbarium specimens.

Progress: Plant referable to Bouteloua curtipendula are of three general types, rhizomatous, stoloniferous, and bunch. The rhizomatous type is widespread in North America. For the most part the rhizomatous plants are tetraploid, with $2n=40$ chromosomes. Aneuploid types with $2n=40+1$, $2n=42+1$ are known from north central Texas. Also, a type with $2n=50$ apparently is frequent in central and north central Texas.

Stoloniferous B. curtipendula occurs in western Mexico. The only cytological record for this type is of a diploid ($2n=20$) plant. Numerous seed collections were obtained in 1959 for research studies at College Station.

The bunch type B. curtipendula is characteristic of semi-arid, rocky or disturbed sites in southwestern U. S. and Mexico. All bunch type plants investigated have had very high chromosome numbers ($2n=80$ to 110) and irregular pollen meiosis. This type has been assumed to be totally apomictic. However, cytological investigations of embryo development by Dr. Emery indicates that some type of sexual reproduction may occur in plants of this group.

Title: A SYNOPSIS OF THE PLANTS OF TEXAS

Leaders: F. W. Gould and O. E. Sperry, Department of Range and Forestry. Cooperating with Soil Conservation Service personnel

Nature of Research: This project has as its purpose the development of a publication containing the following information: 1. Checklist of Texas plants; proper scientific names, accepted common names and synonyms. 2. Distribution of plants by vegetation regions. 3. Short summary of each vegetation region in respect to soils, topography, climate, and dominant vegetation. 4. Index of scientific and common names. 5. Bibliography of publications on Texas flora.

Progress: The research activities in 1959 were concerned with review of literature dealing with taxonomy of Texas plants, examination and recording of data from specimens in the larger herbaria of the state, and field collections of specimens and data to supplement the information available in literature and herbaria. This project is scheduled to be completed in 1960.

Title: EFFECT OF DIFFERENT SYSTEMS OF RANGE ORGANIZATION AND MANAGEMENT ON RETURNS AND RANGE CONDITIONS IN THE EDWARDS PLATEAU

Leaders: P. E. Hildebrand, Agricultural Economics and Sociology;
L. B. Merrill, Sonora Range Experiment Substation 14;
J. E. Miller, Agricultural Economics and Sociology and
R. J. Hildreth

Nature of Research: An objective of this new study is to estimate the most profitable long run combination of livestock and rate of grazing for ranches in the Edwards Plateau Area. Existing experimental data related to physical production from the Sonora Range Experimental Substation will be used in estimating the most profitable ranch organizations. In addition to domestic livestock, wildlife will be considered as a possible economic enterprise for ranches in this area.

Title: ESTABLISHMENT AND MANAGEMENT OF GRASSES AND LEGUMES

Leaders: E. C. Holt, J. A. Long, and P. R. Johnson

Nature of Research: Studies are being conducted to determine the influence of various factors such as temperature and depth of planting on germination and emergence under controlled conditions. A second phase of study involves the influence of time of seeding and fertilizer placement on seedling emergence and establishment under field conditions. Management studies include the influence of clipping practices, fertilization and weed control on yield, vigor, stand density and survival of desired species.

Progress: In a study of germination, emergence and establishment of warm season grasses including Uvalde sideoats grama (Bouteloua curtipendula) Kleingrass (Panicum coloratum), Medio bluestem (Andropogon nodosus), and Pretoria 90 bluestem (Andropogon annulatus), the following information was obtained. Germination was not the same in petri dishes and in soil at various temperatures. The species differed significantly in germination in response to temperature under controlled conditions, the bluestems showing more critical temperature requirements than the other species. Depth of planting also influence emergence under controlled conditions and differed with temperature and species. Under field conditions the species differed in seedling vigor expressed as weight of whole seedlings including root systems. Medio made little above ground growth in 45 days but had a vigorous root system while Kleingrass produced good top and root growth. Kleingrass was the only species emerging when seed were placed in contact with fertilizer. The best general response to fertilizer placement resulted from banded fertilizer below the seed at the time of planting.

Species differ in emergence in response to time of planting. Date of planting studies conducted for several years at Denton, Texas show that slow germinating species such as Dallisgrass and buffalograss respond best to late winter or very early spring planting. Rapidly germinating species such as blue panic become established best with seeding after April 15. Some species with hardy seedlings such as Caucasian bluestem may be seeded any time after late winter. Seed treatments such as chilling and KNO_3 have not influenced emergence and establishment.

The control of weeds (Dock and Croton) in grass stands using 2,4-D or 4(2,4-DB) increased the yield of palatable forage over 20% in pastures at Tyler, Texas in 1959. Weeds in untreated plots utilized plant nutrients valued at more than enough to offset the cost of control. Stand density and root development of the grass sod increased with the removal of weed competition.

Title: GROWTH AND MANAGEMENT OF SELECTED FORAGE SPECIES

Leaders: E. C. Holt and R. D. Staten

Nature of Research: Studies are being conducted of the growth behavior patterns of grasses and legumes in response to environment and as influenced by imposed management practices. These studies have included the response of Kleingrass (Panicum coloratum) and sideoats grama (Bouteloua curtipendula) to frequency of clipping.

Progress: Klein and sideoats grama were clipped 2, 3, and 4 times each in 1959 which was the year following establishment. Both grasses responded similarly to the clipping treatments. Yields were greater with less frequent clipping but neither stands nor apparent vigor were influenced by the treatments. Cumulative growth, determined by sampling all above-ground development at frequent intervals, showed a significant response to clipping treatment. The less frequent clipping resulted in more severe defoliation

which in turn resulted in a rather severe reduction in dry matter accumulation following clipping as regrowth was made from reserves stored in the crown. However, the less frequent clipping resulted in greater total dry matter accumulation indicating that the plants replaced these reserves rather rapidly. Less drastic changes occurred in dry matter accumulation with more frequent clipping probably because the plants did not have the opportunity to build up reserves.

Title: MACHINERY FOR PASTURE ESTABLISHMENT AND MAINTENANCE

Leaders: Elmer B. Hudspeth, Jr., Agricultural Research Service.
Cooperating with Wayne G. McCully, Department of Range and Forestry, George Ellis, Department of Animal Husbandry and Jack Bond, Southwestern Great Plains Field Station, Bushland, Texas

Nature of Research: Equipment and methods of establishing stands of native grass on abandoned cropland and range land.

Progress: 1. Range Pitting and Seeding - Better stands are established on sandy soils than on heavy clay soils.

2. Drying Rate of Seed Zone - Rapid drying rate of soil in the seed zone is the major problem for stand establishment.

3. Use of a film of asphalt sprayed over newly seeded range land shows promise of speeding plant growth and development.

4. Starter fertilizer placed 1 inch to the side and one inch below the grass seed aids in stand establishment on Amarillo fine sandy loam soils. This is true for grasses like green sprangle top and Plains Bristle grass. The starter fertilizer did not seem to benefit the blue stems.

Title: CONTROL OF WEEDS AND IMPROVEMENT OF GRASSES ON RANGES IN WEST TEXAS

Leaders: Don Huss, Department of Range and Forestry; Leo Merrill, Substation 14, Sonora, Texas; Fred Campbell, Substation 14, Sonora; R. A. Darrow, Department of Range & Forestry; P. E. Hildebrand, Department of Agricultural Economics and E. J. Compton, University of Texas Repr.

Nature of Research: Research is conducted on the Texas Range Station near Barnhart, Texas. The 3160-acre experimental range is divided into 17 pastures for comparisons of two rates of stocking with various combinations of cattle and sheep in various grazing systems such as yearlong, 2-, 4- and 6-pasture rotation. Studies are made of responses of vegetation and livestock

production to grazing treatments. Emphasis is placed on the reaction of bitterweed, Hymenoxys odorata to grazing treatment and chemical and mechanical methods of weed control. Methods to improve utilization of tobosa grass or replace it with more palatable species are being tested.

Progress: Higher sheep production has been obtained in combination grazing with cattle than when grazed alone. The same appears true for cattle, but variation between years has occurred. Bitterweed poisoning has occurred more frequently in heavily grazed pastures, particularly under yearlong grazing with sheep. Bitterweed abundance has decreased with light and deferred grazing. Production per animal unit of sheep and cattle has been higher in light grazed pastures and in the 4-pasture rotation, with some variability between years. Production per acre is variable, depending upon rainfall and forage conditions.

Direct relationships between available forage and annual rainfall are apparent. Relationships between soil series and vegetation types have been found. Certain floristic changes are due to climatic factors rather than grazing factors.

Cattle appear to graze tobosa grass more than sheep. Tobosa grass density has been affected very little by grazing and rainfall. Abundance of buffalo-grass and curly mesquite appears to be related to grazing intensity and rainfall. Sideoats grama and cane bluestem are restricted to areas with a history of light stocking.

Title: EVALUATION OF POTENTIALLY DROUGH RESISTANT GRASSES FOR THE SOUTHWEST

Leaders: W. G. McCully, R. A. Darrow and F. W. Gould, Department of Range and Forestry; R. G. Reeves, Genetics Department; H. Walker, Substation 8; C. Jaynes, Substation 8 and Texas Technological College; L. B. Merrill, Substation 14; W. R. Cowley, Substation 15; B. C. Langley, Substation 20; M. J. Norris, Substation 23; Tom Allen, Animal Disease Investigations; Earl Burnett, Soil and Water Conservation Research Division; and E. B. Hudspeth, AERD

Nature of Research: This project is designed to evaluate native range grasses collected under H 717 "Collection and Preliminary Observation of Native Range Grasses," as well as selections obtained from other sources. Primary criteria upon which the suitability of a given accession is judged includes seedling vigor, forage value, seeding characteristics, relative drouth resistance, aggressiveness, and ability to become established under existing range and site conditions.

Progress: More than 80 of the 3000 ecotypes collected have shown superior characteristics. These accessions include Andropogon, Bouteloua, Cenchrus, Leptochloa, Panicum, Pappophorum, Setaria, Tricachne, Trichloris, and certain exotic accessions which may be usable under range conditions. The major emphasis has been on the evaluation of cane bluestem, Andropogon barbinodis;

sideoats grama, Bouteloua curtipendula, and plains bristlegrass, Setaria macrostachya. One selection of sideoats grama collected in Mexico is being released through the Foundation Seed Program, and it is expected that others may be proposed for release in the near future. Work under this project is coordinated with other projects dealing with cytological investigations, insect and disease problems as well as seeding and establishment investigations with agricultural engineers.

Title: EVALUATION OF SUPPLEMENTAL FEEDS FOR BEEF COWS ON NATIVE GRASS PASTURES

Leaders: P. T. Marion, Substation No. 7; C. E. Fisher, Substation No. 8; J. H. Jones, Department of Animal Husbandry; O. J. Barron, Spur Hq. Ranch

Nature of Research: During drouth periods native forage does not supply enough vitamin A to meet the minimum requirements for reproduction in beef cows. Two cow herds were maintained on separate pastures during the winter on the Spur Headquarters Ranch. One herd was fed cottonseed cake fortified with 5,000 I.U. of synthetic vitamin A per cwt. daily. The other herd was fed the same amount of unfortified cake.

Progress: This was the fifth and final year of this project. Cows fed the vitamin A fortified cake during the 1958-59 winter produced a 93% calf crop which averaged 513 lbs. at weaning time. The cows fed the unfortified cake produced an 87% calf crop with an average weaning weight of 498 pounds. The 1958-59 winter was very dry.

Over the 5-year period calf crops averaged 5% higher and weighed from 15 to 28 pounds heavier at weaning.

Title: THE INFLUENCE OF GRAZING MANAGEMENT SYSTEMS ON VEGETATION COMPOSITION AND LIVESTOCK REACTION

Leaders: Leo B. Merrill, Department of Range Management, Substation 14, Sonora, Texas. Cooperating with Robert A. Darrow, Department of Range and Forestry, W. T. Hardy, Substation 14, Sonora, Texas; and E. B. Keng, Soil Conservation Service, Sonora, Texas

Nature of Research: The study is concerned with the relationship of plants and animals to three intensities of grazing use, heavy at 48 animal units, moderate at 32 animal units and light at 16 animal units per section, and at each intensity of grazing use 5 kinds or combinations of livestock, cattle alone, sheep alone, goats alone, cattle and goats combined and cattle, sheep and goats combined. Fifteen pastures are grazed yearlong in this phase of the study. Four additional pastures are used to study the effects of deferred rotational grazing with combined cattle, sheep and goats. Two pastures are

ungrazed by domestic livestock. One of these excludes deer, while low fences allow free deer use on the other. Related studies are conducted on salting practices and deer reactions to grazing use.

Rock ripping and reseeding with native grass species were carried out in June 1958 on approximately 60 acres of land which was in poor condition.

Root plowing and reseeding were done on 50 acres of rocky soil in February 1959.

Progress: The grazing study began February 1949. All pastures involved in the study had been rested from April 1948 until February 1949. This rest improved condition of vegetation materially and affected results obtained from the study. Pastures grazed yearlong at the light rate with all kinds or combinations of livestock made rapid improvement during the first year of the study and remained about constant during the drouth period from 1951 to 1956. The pasture grazed moderately with sheep showed a slight decline in condition during the 1949-1956 period. All moderately used pastures have improved slightly during the above-normal rainfall years of 1957-1959. Pastures grazed yearlong at the heavy rate of use with all kinds or combinations of livestock declined in range condition from 1949 to 1956 but those stocked with sheep alone showed the greatest decline in condition. None of the heavily grazed areas have improved in range condition during the three years of above-average rainfall from 1957 to 1959.

Moderately grazed, deferred rotation pastures showed constant improvement in range condition during the severe drouth years and at present, following three years of above-average rainfall, these pastures have such an abundance of vegetation that it is felt necessary to increase grazing rates to prevent excessive build up of plant litter and possible choking of desirable grass growth. Deferred rotation pastures have made greater vegetation improvement than those completely deferred during the period 1948 to 1959.

Salting a mile away from water has resulted in uniform grazing use on the pastures, although water is located on the side generally most frequented by livestock.

Deer numbers have increased on pastures which have improved in range condition and declined or disappeared on heavily grazed pastures except where cattle were grazed alone.

Rock ripping on shallow soil with an underlying layer of limestone has resulted in establishment of deep-rooted grasses where none grew previously. The practice greatly improved the range condition but the time period is inadequate for final evaluation.

Root plowing was carried out on 50 acres of rocky soil in February 1959 and the area was reseeded to sorghum alnum, blue panic and a mixture of native grasses, Cane bluestem, sideoats grama, and plains bristle grass. Many seedlings of native grasses were established and sorghum alnum made a heavy growth of approximately 6000 pounds of air dry forage per acre. This production would have paid the cost of the operation. Further study is required for final evaluation.

Title: THE RESPONSE OF DESIRABLE SELECTIONS OF NATIVE GRASSES TO CLIPPING AND GRAZING TREATMENTS ON THE SOUTHERN HIGH PLAINS OF TEXAS

Leaders: Chester C. Jaynes, Texas Substation No. 8.
Cooperating with Wayne G. McCully, Harvey Walker, Clark Harvey, Ralph Durham, A. W. Young, and Gerald W. Thomas

Nature of Research: Potentially drought resistant strains of native grass species are being clipped and eventually will be grazed to determine their response to defoliation. Grazing preferences will be evaluated. These studies are designed to give information on the rest requirements of the selected strains so that deferred-rotation grazing designs may be developed for the new strains released to farmers and ranchers for reseeding pastures and grazing lands.

Progress: Data are being collected from dryland plots of selected strains of Leptochloa dubia, Bouteloua curtipendula, Setaria macrostachya, Andropogon barbinodis and Trichachne californica. In the establishment of these strains, good stands were obtained readily with L. dubia, S. macrostachya and A. barbinodis. In sandy loam soils, S. macrostachya gave excellent stands. B. curtipendula and T. californica were established with difficulty. No response from Gibberlic Acid applied to seed prior to planting was noted from any of the grasses.

A selected strain of L. dubia on irrigated soil showed severe damage when clipped at a height of two inches above the soil. No damage was found at clipping heights of either four or six inches. Forage production of crude protein was significantly increased with a 60-40-40 fertilizer. Total forage production increased and protein content decreased as the height of cut above the soil surface was increased from two to four inches and as the time between clippings became longer.

Title: MARKETING OF TEXAS SHEEP AND LAMBS

Leader: Jarvis E. Miller

Nature of Research: Primarily description of marketing practices of Texas sheep and lamb producers. Some information on production practices was obtained.

Progress: Research phase has been completed. Final publications are scheduled for release prior to June 30, 1960. Results of this research which are pertinent to the field of range management include a description of marketing practices of range sheep producers in West Texas. This shows items such as marketing channels used; method, seasonality and place of sale, prices received, costs of marketing, and net returns per head through alternative markets; and changes in marketing practices caused by drouth conditions in 1956.

Title: COLLECTION AND PRELIMINARY OBSERVATION OF NATIVE RANGE GRASSES

Leaders: R. G. Reeves, Department of Agronomy; W. G. McCully, Department of Range and Forestry; Judd Morrow, formerly Department of Range and Forestry, E. C. Holt, Department of Agronomy and L. B. Merrill, Substation No. 14, Sonora, Texas

Nature of Research: Collecting of range grasses was done in 1953 and 1954, with the primary objective of obtaining ecotypes superior to those usually available to ranchers. As these were years of extremely low rainfall, it was expected that ability to withstand drouth might be one of the desirable characters of the ecotypes collected.

Progress: About 3000 accessions of perennial grass species usually recognized as useful on ranges were collected, assigned P.I. numbers and planted in nurseries for preliminary screening. During the next one to three years, they were observed and rated for their desirable characters. By 1957, 83 accessions were considered worthy of intensive investigation, and many additional ones showed some degree of promise. The genera represented in these 83 accessions were Andropogon, Bouteloua, Leptochloa, Panicum, Pappophorum, Setaria, and Trichloris.

In the meantime, a new project, H-988, "Evaluation of Potentially Drouth Resistant Grasses for the Southwest," was initiated to continue the study of the more promising accessions. To date one accession of Bouteloua curtipendula, collected in a dry area a few miles west of Chihuahua City, Mexico, has been approved for release, under the varietal name Premier sideoats gramagrass. Seven additional accessions show possibilities of being useful, but decisions on release of these must await further experimental results.

All records on performance of Premier sideoats, including notes taken on the occasion of collecting, indicate that it withstands drouth especially well. It is rated among the better strains of its species in yield and quality of forage, in seed production and in seedling vigor. It has the unique ability to hold its seed until full maturity, making seed harvesting practicable. In a broad sense, its performance in large areas of western Texas has been more satisfactory than that of any other strain of sideoats grama tested.

Title: PLACE OF KEY HARDWOOD BROWSE SPECIES AS INDICATORS OF PROPER USE OF FORAGE BY CATTLE AND/OR DEER IN PINE-HARDWOOD PASTURES OF EAST TEXAS

Leaders: T. H. Silker, Texas Foreign Service. Cooperating with Texas Agricultural Experiment Station, Substation 22

Nature of Research: To determine: (1) If certain hardwoods browsed by cattle can be useful as reliable indicators of degree of use of associated herbaceous forage, (2) what the annual production of herbaceous and browse forage is under proper use of desirable grasses, (3) if there is similar or different preferential browsing by cattle and deer, (4) if there is damage to pine seedlings, extent and at what level of browse utilization, and (5) extent of understory hardwood control effected by browsing, by animal class.

Progress: Although plant-use and composition data are not yet summarized and analyzed, it appears the following may hold for the heavily-used woods pastures: (1) Deer are putting more pressure on browse plants during the November-April 1 period than are cattle. Cattle are fed protein supplements a portion of the winter. (2) Browse pressure on pine regeneration has been severe when access to good bottomland hardwood mast crops is poor to non-existent (when river overflow precludes use from October-May). Mast and preferred browse plants on adjacent uplands apparently are not sufficient to carry the heavy deer population. (3) Browse pressure is expressed on preferred hardwood plants first. Heavy use of pine regeneration occurs only during late winter as other forage is consumed. (4) Shortleaf browse is preferred (apparently by deer) over loblolly. One winter over 40% of available annual shoot volume was used on shortleaf while 10% use occurred on loblolly. Nutritive analysis of early-winter and late-winter pine needle and pine shoot samples suggest preference is probably related to physical nature of browse. Shortleaf consistently showed a lower fiber content than loblolly, while protein and phosphoric acid levels were nearly the same.

Plant species and seasonal-use preferences are being determined by animal class. Weed grass and browse successional patterns are being catalogued. Pine seed germination and survival has shown a consistant pattern for three seasons, by forage use zones, within the young, moderately-stocked pasture.

Title: SEEDED AND FERTILIZED GRAZED FIREBREAK STUDY

Leaders: T. H. Silker, Texas Foreign Service. Cooperating with
 J. R. Wood, Texas Agricultural Experiment Station and
 Substation 22

Nature of Research: To determine: (1) Response of native and introduced forage species to various rates and ratios of N, P, K and lime, (2) value of such fertilizers and seeding to induce preferential grazing and reduction of flammable material on planned strips of possible value as firebreaks.

Rates, ratios and frequency of fertilizer applications tested, 1949 through 1957 on open longleaf pine ranges on Caddo and Bowie soils.

Progress: Initial response on Caddo soil areas reported in Texas Agricultural Experiment Station PR 1247, May 11, 1950 by T. H. Silker, L. E. Crane and J. C. Smith. Final bulletin, in process, suggests: (1) P_2O_5 applications resulted in greatest preferential grazing, with 60 lb/acre sufficient to form firebreak in one year on Caddo soil (effective in limiting fire spread except under extreme prolonged drought, (2) overseeding increased preferential grazing and common lespedeza was most desirable species, developing most practical stand at 0-60-0 and providing stand with lowest flammability rating, (3) dallisgrass remains green year-round and makes an effective break but may be difficult and slow to establish, (4) on Bowie soils higher rates and combinations of nitrogen and P_2O_5 appeared necessary to get a closely-grazed break the first year, (5) Caddo soils are preferred treatment areas, where 60 lbs P_2O_5 at establishment and every 2 years thereafter appears sufficient to maintain seeded common lespedeza and a closely grazed firebreak, and (6) slender bluestem is more persistent in maintaining stands than other bluestems--its predominance suggests use as an indicator the range is below its potential.

Title: FITTING IMPROVED SOIL, WATER, CROP, AND LIVESTOCK MANAGEMENT
 PRACTICES INTO CONSERVATION FARMING SYSTEMS FOR THE TEXAS
 BLACKLAND

Leaders: R. M. Smith, Substation No. 5, Temple, Texas; R. C. Henderson,
 Substation No. 5, Temple, Texas; Ralph H. Rogers, USDA-FERD,
 Department of Agricultural Economics and Sociology; John H.
 Jones, Department of Animal Husbandry; J. W. Collier, R. J.
 Hervey, E. D. Cook, Substation No. 5, Temple, Texas

Nature of Research: One 8-acre pasture of native grasses which has never been plowed is grazed with yearling steers on a seasonal basis in accordance with growth, but never intense enough to result in a shortage of forage quantity for the animals. Data obtained include the periods and pounds of gain for individual animals. As an indication of possible species changes, basal diameter measurements in square foot areas along established line transects are made at intervals of several years.

Progress: From 1947 through 1951 this pasture was grazed by schedule from mid-April to early July, with average steer gains of 90 pounds per acre and 1.60 pounds per head, daily. Grazing in accordance with growth, 1952 through 1959, resulted in average gains of 122 pounds per acre and 1.62 pounds per head, daily. Species measurements in the fall of 1952 and again in the fall of 1959 indicated some decreases in basal diameters of little bluestem, sideoats grama and Texas wintergrass, with considerable increase for Texas cupgrass. No interpretations of species changes have been made.

Title: DISTRIBUTION AND CONTROL OF POISONOUS PLANTS ON TEXAS RANGE
LANDS

Leaders: Omer E. Sperry and George Sultemeier

Nature of Research: This is a State-wide project set up to determine the distribution, abundance, ecological aspects, toxic nature, conditions of poisoning, and to establish management practices and methods of control of the plants poisonous to livestock.

Progress: Current research now being directed to bitterweed (Hymenoxys odorata), Coyotillo (Karwinskia humboldtiana) and Mescal bean (Sophora secundiflora).

Bitterweed control satisfactory with one pound (acid equivalent) of the ester formulation of 2,4-D per acre in early flower stage when moisture conditions good. Water as carrier 15 or more gallons per acre with ground equipment, 4 gallons by air. Addition of diesel oil and combining 2,4,5-T adds effectiveness when spraying plants in early maturity. Spraying of mature plants or when moisture conditions low, ineffective.

Coyotillo control satisfactory with pelleted fenuron applied in spring and basal treatments of 4 to 6% 2,4,5-T, brushkiller and Silvex (ester formulations) applied after late spring and early summer rainfall. Top kill, but limited total plant kill obtained with foliage sprays.

Mescal bean susceptible to fenuron and basal treatments according to 1959 screening tests.

Title: STRATEGIES FOR ORGANIZING AND OPERATING DRYLAND ROW-CROP FARMS AND RANCHES IN THE HIGH AND ROLLING PLAINS OF TEXAS TO MEET VARIABLE CLIMATIC AND CHANGING ECONOMIC CONDITIONS

Leaders: D. R. Tefertiller, P. E. Hildebrand, and D. S. Moore,
Department of Agricultural Economics and Sociology

Nature of Research: In cooperation with Soil Conservation Service, the profitability over time of various range improvement practices will be estimated. The probability of success in applying Great Plains Conservation Program Contract Practices in Texas will be estimated in order to compute returns and costs over-time. Site, range conditions, distribution of rainfall, temperature, date of practice, size and type of unit, and follow-up practices are variables to be considered in estimating the probability of success in applying these conservation practices.

Title: GRAZING MANAGEMENT AND NUTRITION FOR COW-CALF OPERATIONS IN THE ROLLING PLAINS

Leaders: William J. Waldrip, P. T. Marion, and R. J. Hildreth

Nature of Research: This study on an 11-section ranch in Throckmorton County, Texas, is designed to compare the effects and interrelationships of 3 rates of stocking, 3 systems of grazing and 3 levels of winter nutrition upon livestock, vegetation, and soil and water conservation. Livestock numbers may be adjusted semi-annually to achieve desired levels of utilization.

Other studies include range improvement pilot studies in reseeding, brush and weed control and wildlife conservation. This study has just been initiated (Spring, 1960).

Title: METHODS OF SEEDING SAGEBRUSH AND JUNIPER RANGES AND EFFECTS OF VARIOUS GRAZING TREATMENTS UPON RESULTING STANDS

Leaders: C. Wayne Cook and L. A. Stoddart. Cooperating with Bureau of Land Management

Progress: Drought years such as 1959 showed that all seeded grasses produce about the same livestock responses and are no better than native range for spring grazing.

The control of annual weeds with herbicides is generally beneficial for seedling establishment. In some years the benefits are more pronounced for seedlings during their first growing season, but in other years the benefits are greater during the second year of growth.

Control of sagebrush from invading seeded wheatgrass stands by means of herbicides increased dry weight yield as much as 600 pounds per acre.

The application of as much as 20 pounds of nitrogen per acre on seeded wheatgrass areas increased yields as much as 500 pounds per acre. In addition, protein content and palatability was materially increased even over the second year after application.

Future Plans: The same work plan will be followed in 1960 except that application of herbicides for the control of rabbit brush in seeded areas will be included.

Title: THE INFLUENCE OF SMALL MAMMALS UPON RANGE FORAGE PRODUCTION AND AVAILABILITY

Leaders: DuWayne L. Goodwin, and L. A. Stoddart, Department of Range Management and J. B. Low, Department of Wildlife Management

Progress: Methods of determining forage preference of jackrabbits and seasonal shift in use of forage species were investigated. The recognition item in feces technique was judged to be unsatisfactory because of the similarity in gross morphology of sections of plant species consumed. A grid-point ocular examination technique was devised and yielded useful results. Rabbit preference for shrubs during winter and early spring was demonstrated. This was followed by a shift to grasses during late spring and summer. These observations are to continue until a full year of observation has been completed.

Confinement of rabbits in pens to determine actual quantities of forage consumed was also studied. Use of paired plots to measure quantities of forage removed proved to be better than use of similar numbers of randomly located plots because of the restriction on number of plots that could be established.

Future Plans: Analyze, evaluate and summarize all data collected in Tintic Valley, Eureka, Utah; complete study of methods of determining forage preferences and seasons of use; continue study of effect of controlled population of jackrabbits on native vegetation.

Title: RANGE AND PASTURE DEVELOPMENT AND USE

Leaders: Phil R. Ogden, Department of Range Management, Darrell Matthews, Department of Animal Husbandry, and L. A. Stoddart, Department of Range Management.

Cooperating with Bureau of Land Management, Soil Conservation Service, and Int. Forest and Range Experiment Station.

Progress: A study of temperature and moisture evaporation in furrows of a deep-furrow seeding method was continued in 1959. Both maximum and minimum temperatures were higher in the bottoms of the furrows when compared to the nonfurrowed control. Evaporation from atmometer bulbs placed in the furrows was as much as 10 percent less than evaporation from atmometers not in furrows despite the slightly higher temperatures in the furrows.

Aspen treatment and seeding studies showed a material increase in numbers and increase in herbage yield of native and seeded species when a dense aspen canopy was reduced by clear-cutting or chemical treatments. The density of the aspen canopy and the amount of understory vegetation had a great influence on the success of an aerial seeding of smooth brome grass, orchardgrass, and tuatara oatgrass into an aspen stand.

Future Plans: We shall continue the study of understory vegetation development resulting from aspen treatments, and the cost and returns study comparing permanent grasses and annual grains planted by deep-furrow seeding with "high water" irrigation. A physiological study of intermediate wheatgrass as influenced by grazing treatments at varying moisture levels will be initiated, and a grazing intensity study on dryland crested wheatgrass pastures also begun.

WASHINGTON

Title: FOREST VEGETATION OF THE NORTHERN ROCKY MOUNTAINS

Leader: R. F. Daubenmire, Department of Botany

Objectives: A classification of forest vegetation in eastern Washington and northern Idaho, as based on reconnaissance study, was published by Daubenmire in 1952. The current project, supported by a 5-year grant from the National Science Foundation, aims to study the same vegetation, but (1) to analyse it in greater detail, (2) to increase the number of study sites, and (3) to expand the area covered wherever the same forest association can be found beyond the area of initial interest. Old climax stands are the focal point of study, but their interpretation requires consideration of burned areas as well. The results should permit a more precise description of variation in vegetation composition and of the biotic potentialities of habitats, and should show the extent to which the previous classification may need modification. They should find use in managing forest lands for timber, livestock, game, or water yield. No reports are planned until the entire study is completed.

Title: RELATIONSHIP OF NUTRITION TO THE INCIDENCE OF THE ANOMALY CROOKED CALVES.

Leaders: I. A. Dyer, Department of Animal Science and G. A. Harris, Department of Forestry and Range Management

Objectives: 1. Isolation of the natural subdivision: vegetation, soil, or range conditions wherein "crooked calf" disease is occurring.

2. Determining of nutrient content of the forage, and the chemical analysis of soils and water occurring within the isolated subdivision as determined in (1) above.

3. Determination of the occurrence of suspected poisonous plants in relation to the occurrence of "crooked calf" disease.

4. Conducting feeding trials to determine possible nutrient deficiencies of range forage or mineral deficiencies which may be responsible for the occurrence of "crooked calves."

5. Experimentally producing "crooked calves" through the manipulation of diets.

Progress: Two adjacent ranches have been selected for intensive study. One of these has no past history of crooked calves, the other nearly 100% crooked calves over the past few years. Both are small ranches of approximately 500 acres.

Soil, water and forage samples collected from the experimental ranches have been analyzed. There is no apparent difference in soil composition in pH, O.M., Ca, P and K. A more complete analysis is being made. The water samples were analyzed spectrographically. The preliminary data indicate that Mn is much higher in the water from the ranch in which no crooked calves have been produced. A chemical analysis of the forage samples from the two ranches shows a higher protein and ash content in the forage from the ranch on which the crooked calves are produced. This perhaps reflects good "range management" and probably has little bearing on the problem.

Gestating rats have been fed diets high in lupine, cheatgrass smut, and spartaine contents. Also, low energy diets with the above stresses have been studied. Water from the crooked calf ranch has also been studied in gestating rats. To date, no abnormal young rats have been produced.

No conclusions can be made at this time.

Title: COMPETITIVE RELATIONSHIPS BETWEEN CHEATGRASS (BROMUS TECTORUM L.), BLUEBUNCH WHEATGRASS (AGROPYRON SPICATUM (PURSH.) SCRIB.) AND OTHER IMPORTANT PERENNIAL GRASSES OF THE COLUMBIA BASIN

Leader: Grant A. Harris, Department of Forestry and Range Management

Objectives: 1. To describe and evaluate the basically inherent anatomical and physiological characteristics of these species in relation to their competitive efficiency.

2. To evaluate the response of these species to several environmental factors as related to competitive efficiency.

3. To isolate and evaluate the phytosociological factors involved in these competitive relationships.

Procedures: 1. To examine organs of the two species microscopically and describe anatomical structures.

2. Measure site factors associated with solid stands of each species through the critical spring growing period.

3. Determine the degree of competition in field plots and in greenhouse pots, by measuring yields under competitive situations.

Title: RELATIVE VALUE OF SELECTED RANGE GRASSES FOR SPRING FORAGE

Leader: Grant A. Harris

Objectives: 1. To test the early spring grazing value of four seeded grass species for cattle.

2. To develop and improve methods of measuring the seasonal grazing value of seeded range grass species.

Progress: The relative spring forage value of four selected grass species was tested for the fifth time in a cattle grazing trial. Each of the four pastures, 5.84 acres in area, supported six cows with calves for the 24-day period of May 14 to June 7, 1959. Phenological observations indicated that plant development was delayed about two weeks, compared to 1958. This was presumably the result of differences in the weather during the two spring seasons.

In November 1958, half of each unit area was treated with 200 pounds and half with 400 pounds of 16-20-0 fertilizer per acre. It is estimated that this treatment forced the grasses to readiness for grazing use about two weeks earlier than the unfertilized grass, and apparently increased the grazing capacity from about 96 cow days per pasture in 1958 to about 144 cow days in 1959.

Intermediate wheatgrass continued to produce more pounds of gain on the livestock grazing in the trial than any of the other three species of grass. Crested wheatgrass produced essentially the same cow gains, and pubescent wheatgrass slightly more calf gains than intermediate wheatgrass, but the latter provided high gains for both cows and calves, and for combined gains was unsurpassed. Pubescent wheatgrass has excelled in calf weight production for the past two years, strengthening the claim this species has in this regard.

From an analysis of "pounds per day" gain figures for the years 1954, 1955, 1956, 1958 and 1959, it is apparent that management factors have influenced gain very strongly. When units have been grazed heavily, gains have been reduced. Likewise, earliness of grazing in relation to phenological development is suspected of influencing gains. Because yield and phenological development vary among species, it would be difficult to remove these factors as variables. It is however, important to recognize the problem and make provision for standardizing procedures from year to year.

Title: IMPROVED MID-SUMMER RANGE FORAGE FOR BEEF CATTLE IN EASTERN WASHINGTON

Leader: Grant A. Harris, Department of Forestry and Range Management

Objectives: To test the mid-summer grazing value of selected grass species for beef cattle under eastern Washington range conditions.

Progress: Six units, each twenty acres in size, are being seeded in two replications to three species or combinations of species suitable for mid-summer grazing use. These are (1) Whitmar (Agropyron inerme), (2) intermediate wheatgrass (Agropyron intermedium), and (3) intermediate wheatgrass plus alfalfa.

These will be grazed and animal gains determined during late June and July. Forage yield studies, utilization surveys, and chemical analyses of forage samples will also be made.

Stands of the forage species are presently being established.

Title: IMPORTANT RANGE PROBLEMS OF EASTERN WASHINGTON

Leader: Grant A. Harris, Department of Forestry and Range Management

Objectives: 1. To discover the important range problems of eastern Washington.

2. To assign priorities to these problems as a means of giving direction to the Washington Experiment Station Range Research program.

Progress: Based upon data gathered in this project, the sub-division of eastern Washington into six range management regions was proposed. The classification groups areas having common range livestock operational problems, resulting from similar topography, precipitation, temperatures, vegetation, soils, and economic factors. Problems should be considered by regions for greatest significance. The proposed sub-divisions follow:

1. Okanogan Highlands region
2. Channel scablands region
3. Cascade east slopes region
4. Semi-desert region
5. Southeastern canyon-mountain region
6. Palouse hills region

A county-by-county survey of range problems in eastern Washington has been underway for the past four years. A compilation of range problems has been made and priorities assigned by representatives in twenty counties. The

following six range problems are listed in order of priority as rated by these non-technical stockmen.

	<u>Region of Importance</u>
1. Balanced seasonal grazing capacity	1, 2, 4, 5
2. Seasonal variation in nutritive value of range forage	1, 4, 5
3. Reduction of forage production by brush encroachment	1, 3, 4
4. Stock water development on poorly watered ranges .	4
5. Anaomaly crooked calves	2, 4
6. Economics of range land use	1, 5

Title: SOIL CLASSIFICATION AND SURVEY

Leaders: Warren A. Starr and Raymond A. Gilkeson, Department of Agronomy. Cooperating with Soil Conservation Service and U. S. Forest Service

Objectives: To complete the soil survey of the State of Washington.

Progress: 1. Soil Classification and Survey

Distribution of soil variance on rangelands of the state are being observed, recorded, and appropriate descriptions being made in regular Soil Classification and Survey programs, cooperative with Soil Conservation Service and U. S. Forest Service.

- a. Lands within 76 Soil Conservation Districts, state-wide, Cooperative Soil Survey with Soil Conservation Service classification and mapping.
- b. Range soils on the Colville Indian Reservation have been mapped and classified cooperative with Soil Conservation Service and Bureau of Indian Affairs.
- c. Range soils on the Colville National Forest are being investigated, described, classified and mapped on a current soil survey, cooperative with U. S. Forest Service

2. Bench Mark Soil Study

Between 40 and 50 soil series which occur on range lands are included in the Bench Mark Soil Study in Washington. In this study, key soil series are selected which have prominence in morphological and genetic characteristics and which have extensive distribution. Data will be collected on these series as to description, classification, physical and chemical analysis, & land use & management data. Reports will be made of the findings, either as individual reports of soil series, or as reports covering groups of soil series.

WYOMING

Title: A STUDY OF RANGE CONDITION CLASSES IN THE JACKSON HOLE
REGION OF WYOMING

Leader: A. A. Beetle

Objectives: To determine range condition classes for Teton County, Wyoming, for all the major range types.

Progress: The vegetation in Jackson Hole is something like the boulder of the local moraines. They are at once old, some of them dating back to very early Geologic time, but at the same instance, they are young, having been shaped within the last million years by glaciers. Similarly, the plants and floras of Jackson Hole represent old species and old floras, but they have been severely readjusted in their occurrence in Jackson Hole by the same events which shaped the glacial boulders. Comparisons have been made with other similarly young areas and evidence has been found that the whole process of deglaciation has been more rapid than previously assumed; that the climate is not yet static after the great disturbances of the ice age, and that trees are invading some areas as the soils develop.

It is now (1959) 50 years since the heavy death losses in 1909 brought attention to the fact that game populations were larger than the winter range could support. Fifty years of feeding has partially solved one problem but has created another which will prove to be even more difficult of solution.

While heavy winter death loss during unusually heavy snows first attracted attention to the severity of the problem, the attendant depletion of the shrubs of the area was also recorded.

The initiation of winter feeding did not restore the shrubs to their normal form, since the game continue to eat woody materials where available in addition to hay. Winter feeding by eliminating the winter range as the factor in herd size releases the population for additional growth in numbers until a new limiting factor asserts itself. This new factor has proven, for the elk, to be the summer range.

Title: THE SELECTION AND MANAGEMENT OF GRASSES FOR MOUNTAIN RANGES

Leader: A. A. Beetle

Objectives: Exploration for ecotypes of *Danthonia*, and a study of methods of planting this crop, both from normal seeds and from cleistogenes.

Title: METHODS OF ESTABLISHMENT OF BROWSE SPECIES ON RANGELAND

Leaders: A. A. Bettle and W. M. Johnson

Objectives: To break dormancy of shrub seeds easily and readily, and to learn more about seedling establishment.

Progress: A field study has been made of the distribution of shrubs in Teton County (an area of Wyoming comparatively rich in species exhibiting this life form) and of the occurrence in various species, of which Amelanchier was chosen for special greenhouse study.

Problems involved in germination of the seed of Amelanchier have been found to be similar to those of the more studied Purshia, and results may be expected with continued study. On the other hand, the problems involved in the germination of seeds of Rosa, collected both in the wild and at the Cheyenne Horticulture station, have proven much more difficult.

Title: A STUDY OF RANGE CONDITION CLASSES AND METHODS OF RANGE IMPROVEMENT IN WYOMING

Leaders: H. G. Fisser, A. A. Beetle, R. L. Lang, and D. R. Smith

Objectives: 1. To determine range condition classes for various types of vegetation within the study area.

2. To test various methods of range improvement such as pitting, seeding, and control of undesirable species.

Procedures: Field procedures of the western Wyoming Big Horn and Wind River Basins surveys were initiated by personnel of the University of Wyoming, Division of Plant Science, during 1959. Transects of square foot plots were read on 220 sites as part of the vegetative type inventory and classification. Data related to general site characteristics (e.g., soil slope, exposure, stock use, elevation, etc.) were noted to aid in determination of condition class and site potential. Several relict areas and fenced exclosures were studied.

Progress: Range improvement studies were established in October of 1959 on three big sagebrush sites, on two Gardner's salt sage sites, and on one greasewood site. Twelve species were planted with the Wyoming Range Seeder. These species were Pampean brome grass, Gardner's salt sage, Indian ricegrass, Tualatin oatgrass, Russian wildrye, Whitmar beardless wheatgrass, green needlegrass, crested wheatgrass, pubescent wheatgrass, Amur intermediate wheatgrass, western wheatgrass, and tall wheatgrass. Crested wheatgrass was broadcast on part of a pitted area next to the reseeded plot.

Future Plans: Additional information will be recorded on sites already studied. New sites will be studied and mapped. A series of about 100 rain gauges will be established throughout the study area to observe the moisture pattern. Future plot studies to determine the feasibility of sagebrush control as a means of range improvement will be established.

Title: THE IMPROVEMENT AND USE OF RANGELANDS THAT ARE THREATENED
BY HALOGETON GLOMERATUS

Leaders: Duane Galliner and Dixie R. Smith. Cooperating with Bureau of Land Management and Bureau of Reclamation

Objectives: 1. To study the ecology of halogeton and of the plant communities with which it is associated.

2. To determine the effect of different intensities of grazing upon the spread or containment of halogeton.

3. To evaluate range improvements in relation to the presence of halogeton.

Progress: Experimental pastures were established in 1956 on saltsage (Atriplex gardneri) range near Greybull, Wyoming. These pastures are being used to relate intensity of winter sheep use to animal gains, vegetative cover and production. Additional pastures have been recently established near Worland, Wyoming, to evaluate like systems in similar terms.

Long-term ecological studies have been started which utilize vegetative cover, soil and climatic data obtained from stations, both subject to and protected from grazing.

Title: MECHANICAL TREATMENT AND SEEDING OF RANGELANDS

Leaders: Robert L. Lang, Department of Range Management, Clarence Becker, Department of Agricultural Engineering. Cooperating with Frank Rauzi, Agricultural Research Service

Objectives: 1. To test grassland drill and Wyoming range seeder as a possible means of introducing species into rangeland and their effect on grazing capacity.

2. To test the effectiveness of repitting old treated areas for increasing forage production.

3. To design or adapt presently available equipment to introduce species in existing stand of native vegetation.

Progress: The past season was extremely dry and the grazing period was shorter than last year. Pastures treated with the range seeder were stocked 25 percent heavier than the pastures treated with the sod drill or the range pitter. A total of 79 sheep days of grazing per acre was obtained from the pastures treated with the Wyoming range seeder and 59 and 47 sheep days of grazing per acre, respectively, was obtained from the pitted pastures and the pastures treated with the sod drill. Lamb gain per acre was 13 to 16 pounds greater from the pastures treated with the Wyoming range seeder than from the pastures treated with the range pitter or the sod drill.

Title: INTENSITY OF GRAZING STUDY ON THE SHORTGRASS PLAINS

Leaders: Robert L. Lang, Department of Range Management. Cooperating with Frank Rauzi, Agricultural Research Service

Objectives: 1. To determine the long-time effect of different intensities of use on the vegetation composition and density in the shortgrass plains.

2. To study the effect of light utilization rate of recovery of overgrazed shortgrass range and sheep gains from these pastures as compared with good range, lightly and moderately grazed.

Progress: A total of 27 sheep days of grazing per acre was obtained from the light use pastures and 41 sheep days of grazing per acre from the medium use pastures. Average lamb gain per head from the pastures lightly grazed since 1955 was 48 pounds or four pounds less than from the pastures grazed lightly since 1945. Average lamb gain per head from the moderately grazed pastures was 53.5 pounds. Lamb gain per acre averaged 29.1 pounds from the moderately grazed pastures. This is an average of 10.8 pounds more than from the pastures lightly grazed since 1945 and 12.1 pounds more than from the pastures lightly grazed since 1955.

Title: GAME/LIVESTOCK COMPETITION IN THE JACKSON HOLE REGION OF WYOMING

Leader: Dixie R. Smith. Cooperating with Wyoming Game and Fish Commission

Objectives: 1. To determine the degree of utilization on major browse species (the critical life-form) by game and livestock.

2. To delimit the areas, and intensity of competition.

Progress: Data collected since 1957 have suggested no significant degree of competition between the two types of animals. Utilization by game during the winter has in many instances exceeded the accepted proper use standards. The critical status of browse plants in the area is assumed to be entirely due to use by game.

Relative palatability of browse is in the order of willow, rubber rabbitbrush, aspen, serviceberry, and chokecherry.

The extreme variability inherent within these utilization data emphasize the need for more intensive work combined with realistic stratification of the range.

Title: COMPARISON OF ROTATION GRAZING AT TWO INTENSITIES WITH SEASON-LONG SUMMER GRAZING IN TERMS OF VEGETATION AND STEER GAINS

Leader: Dixie R. Smith, Department of Range Management. Cooperating with U. S. Forest Service, Bighorn Permittees Association, and Wyoming Board of Natural Resources

Objectives: The objectives of this study are to determine on areas grazed heavily, moderately and lightly in the past, the effect of (1) moderate continuous summer grazing, (2) moderate 3-unit rotation grazing and (3) heavy 3-unit rotation grazing on cover and production of vegetation, uniformity of utilization and weight gain of steers.

Progress: Experimental pastures were established in 1959 on subalpine grassland of the Big Horn Mountains. No conclusive treatment data are presently available.

Title: LIVESTOCK DISTRIBUTION STUDIES

Leader: Dixie R. Smith

Objectives: 1. To evaluate methods of obtaining more uniform livestock distribution through chemical treatments of selected rangeland sites.

2. To delimit the area of effect and determine the most economic rate and method of application.

3. To collect additional information on the effects of treatment on forage production, nutritive content and botanical composition.

Progress: Nitrogen and 2,4-D applications on subalpine grassland have resulted in increased harvest of forage. However, the latter has far greater effects in terms of production and harvest of grass.

CROPS PROTECTION RESEARCH BRANCH

CROPS RESEARCH DIVISION

AGRICULTURAL RESEARCH SERVICE

Title: UNDESIRABLE RANGE PLANTS AND THEIR CONTROL

Research on the control of weed and brush species in the rangelands is conducted in the Crops Protection Research Branch, Crops Research Division, Agricultural Research Service, U. S. Department of Agriculture, in the 17 western states in cooperation with the State experiment stations of Texas, Oklahoma, Nebraska, Arizona, Utah, Nevada, Idaho, Oregon, and Washington. Research is designed to give information concerning range weeds and improved methods for their control.

H. M. Hull, Tucson, Arizona, found that a new nonionic, acid-stable surfactant consisting essentially of glycerol monostearate increased the absorption and translocation of 2,4,5-trichlorophenoxy-acetic acid [2,4,5-T] in mesquite at a pH of 3.0. Under most conditions, lowering the pH of a formulation will give variable results, depending on the type of surfactant and herbicide used. However, the new surfactant in combination with the sodium salt of 2,4,5-T resulted in herbicidal responses which were inversely correlated with pH within the range of 3.0 to 7.0. Another widely-used nonionic surfactant in these investigations gave distinctly inferior results at the lower pH levels.

Variation in response of apparently identical trees to the effects of herbicides has never been satisfactorily explained. In an investigation to study the reason for such variation, leaves were collected in June from 2 adjacent mesquite trees of very similar appearance with the exception that they had foliage of a markedly different hue. Chlorophyll in the leaves varied considerably in their ratio of chlorophyll a to chlorophyll b. After treating both trees with 2,4,5-T, they demonstrated a differential susceptibility to the compound. The tree with the darker gray-green foliage and greater proportion of chlorophyll b was more resistant. However, there is apparently no physiological reason why trees of varying foliar pigmentation should respond differently to a herbicide.

F. H. Tschirley, Tucson, Arizona, has found that the experimental error in experiments of aerial application of herbicides to mesquite using four replications and 50-tree samples per replication, does not permit the detection of 9 percent mean differences at greater than 0.80 probability. Increasing the sample size to 100 trees improved the probability of detecting the same mean difference to 0.95. Eight or nine replications with 100 tree samples was needed to detect a 5 percent difference at 0.95.

Correlation analysis showed that mesquite trees on ridges were affected more by herbicides than trees located in drainages. This is important in experimental work and in commercial operations.

In College Station, Texas, H. L. Morton showed that the response of retama seedlings to 2,4,5-T was greater at 90°F. than at 70°. Higher treatment concentrations and temperatures were required to bring about the same response to 2,4,5-T in retama than in mesquite.

Evidence from plant responses and assays of radioactivity indicate that radioactive 2,4-dichlorophenoxyacetic acid (2,4-D) and 2,4,5-T move downward in mesquite seedlings exposed to 70°F., but movement is practically nil in whitebrush seedlings. Mesquite seedlings exposed to 100° after application of 2,4-D contained little radioactivity after 24 hours while whitebrush seedlings exposed accumulated most of the detected radioactivity in the growing tip of the stem and lesser amounts in stems and leaves above the point of application.

Mesquite seedlings growing at a relative humidity level of 30-35 percent for 5 weeks were taller, produced more dry weight and contained more nitrogen than seedlings growing at a relative humidity level of 90-95 percent.

Mesquite, retama, and live oak seedlings exposed to low (25-30 percent) relative humidity for at least 5 days after treatment gave lower responses to 2,4,5-T than seedlings exposed to high (90-95 percent) relative humidity.

In greenhouse evaluations in Texas, 2-methoxy-3,6-dichlorobenzoic acid showed higher toxicity to mesquite, whitebrush, retama, and live oak than 2,3,6-trichlorobenzoic acid (2,3,6-TBA). Its toxicity to mesquite and whitebrush was not as great as that of the compounds now recommended for the control of these species but it was the most toxic material applied to live oak.

At Flagstaff, Arizona, T. N. Johnsen, Jr., found that pelleted fenuron was effective for treating individual alligator juniper trees. This method shows promise on scattered invading trees on range lands or as a "tool" to control alligator junipers in ponderosa pine stands in the Southwest. The polychlorinated benzoic acid shows promise for use as a foliage spray on one-seed and Utah junipers. Foliage treatments with 2,3,5,6-tetrachlorobenzoic acid (2,3,5,6-TBA) shows promise of controlling alligator juniper.

Application of polychlorinated benzoic acids to alligator juniper stumps in Arizona during late spring prevented sprout development in limited field tests.

At Tempe, Arizona, E. A. Davis found the optimum growth conditions for turbinella oak were hot days (above 98°F.) with partial shade (3,000 foot candles) and warm nights (above 70°). Fundamental research on the growth pattern of turbinella oak showed that most seedlings grew intermittently in definite rhythmic patterns. Seedlings had different growth patterns and their rate of growth varied greatly. Growth during the night and day proceeded at about the same rate. Growth was not limited by seasonal changes in photoperiod but continued on short days under warm conditions. These results are of value in growing plants for experimental purposes and they provide a basis for a study of the relationship between stage of growth and susceptibility of chaparral to herbicides.

An experiment was initiated in 1958, by D. N. Hyder and F. A. Sneva at Burns, Oregon, to find methods of selectively removing sagebrush (Artemesia tridentata) from bitterbrush (Purshia tridentata). Sprays of 2,4-D were much less injurious to bitterbrush than 2,4,5-T but was about equally effective for controlling sagebrush. The average mortality of the bitterbrush from 1.5 pounds per acre of an ester of 2,4,5-T was 24 percent while 3 pounds per acre of 2,4-D killed only 18 percent. It appears that early spraying with 1-1/2 pound per acre of 2,4-D will be best for selective control of sagebrush in bitterbrush.

Hyder and Sneva also found that spraying death camas with 1-1/2 pound per acre of an ester of 2,4-D early in the spring in Oregon gave good control. Death camas mortality decreased rapidly as spraying was delayed. Average results were: 91, 82, 31, 22, 14, and 5 percent killed, respectively, when sprayed on April 30, May 14, June 2, June 13, June 23, and July 9.

H. M. Elwell, Stillwater, Oklahoma, found that drift from an oil-in-water emulsion of an ester of 2,4,5-T aerially sprayed in a 10 mile per hour cross wind moved 440 feet downwind from the flight swath as noted by the herbicidal effect on Illinois bundle flower. An invert emulsion of an ester of 2,4,5-T under the same conditions drifted 320 feet.

Greenbrier was effectively defoliated with 3 pounds of low volatile ester of 2,4,5-T in 20 gallons of water applied as a foliage spray in Oklahoma.

W. C. Robocker, Pullman, Washington, has summarized progress in a regional study of the effects of depth of planting on longevity of seeds of halogeton (Halogeton glomeratus). The first and second years' accumulative data showed 100 percent germination of the black seeds in 5 state locations and at burial depths up to 6 inches. In this second year, the accumulative total surface germination of brown seeds increased from 60 percent to 81 percent in Washington; from 2 percent to 100 percent in Utah; and from 3 percent to 49 percent in Idaho. Germination of brown seeds at 1, 3, and 6-inch depths averaged 3 percent, except in Washington where it averaged 19 percent. Halogeton plants were established in the field from brown seeds in Idaho.

In Logan, Utah, M. C. Williams and E. H. Cronin applied 128 new chemicals as foliage sprays and evaluated them for their effectiveness in controlling halogeton under greenhouse conditions. Thirty-six of the new compounds were found to be more effective in controlling halogeton than any of the compounds used to control this species at the present time. In studies on the penetration, absorption, and translocation of herbicides in halogeton and related range weeds, fluorescent dyes were employed to study the penetration and translocation of solutes. The study showed that an absorption barrier exists on the surface of the halogeton plant to solutes in an aqueous medium.

In studies on the accumulation of selenium in halogeton in Utah analysis of field-grown halogeton have shown that selenium usually does not accumulate in halogeton in quantities greater than 100 parts per million. These studies suggest that halogeton would not normally be toxic due to the selenium content alone. In studies on the effect of K and Na on the growth of halogeton, it was shown that halogeton can survive with sodium alone but

dies when both K and Na are absent. The data indicate that K cannot be entirely replaced in that plants deprived of K are far from normal in appearance but it can be replaced to the extent that life can be sustained.

R. H. Haas in experiments at Twin Falls, Idaho, on the preemergence control of halogeton (Halogeton glomeratus Mey.), learned that: (1) polychlorobenzoic acid (PBA) is inferior to 2,3,6-TBA for halogeton control, (2) the amine salt of 2,3,6-TBA is as effective as the sodium salt formulation for the first year's control of halogeton, and (3) two pounds acid equivalent per acre of either the sodium or amine salts of 2,3,6-TBA are required to provide adequate control of halogeton for one year. Black seeds produced on plants surviving chlorobenzoic herbicide treatments are viable and germinate normally.

The second year evaluation of six foliage-spray treatments for the control of tall larkspur (Delphinium occidentale Wats.) when in the bud stage in Idaho indicate that: (1) ester formulations of 2-(2,4,5-trichlorophenoxy) propionic acid (silvex) and 2,4,5-T were more effective than esters of 2,4-D or 2-methyl-4-chlorophenoxyacetic acid (MCPA) when applied at rates of 4.0 and 8.0 pounds per acre, (2) silvex and 2,4,5-T provided 70 and 84 percent control, respectively, and 2,4-D provided only 27 percent control when applied at the rate of 4.0 pounds per acre, and (3) the forage yield of resident grasses was significantly increased on both rates of 2,4,5-T and silvex.

R. A. Evans at Reno, Nevada, found that growth and vigor of halogeton was affected by kinds of soil on which it was grown. Halogeton yields on sierozem soils were 10 times those on desert soils. High P, K, N and about neutral pH were correlated with highest halogeton yields. Low cation exchange, low Mg, N and P, and greatest range of pH from neutral were correlated with lowest yields. No macronutrient treatment was effective in equalizing the growth of halogeton among 3 sierozem soils. Deficiency of a micronutrient or micronutrients in 2 of the soils seems to be suggested as at least a partial explanation of differences among these 3 soils.

In greenhouse studies at Reno, Nevada, soil moisture depletion was greater and growth of crested wheatgrass reduced with increasing densities of cheatgrass. Crested wheatgrass seedling growth was decreased early in the season at the high densities and soil moisture was depleted more rapidly. Cessation of growth of both species occurred when 15 bars of soil moisture suction was reached.

Applications by T. N. Johnsen, Jr., of 1 pound per acre of propylene glycol butyl ether esters of 2,4-D gave good control of pingue in Flagstaff, Arizona.

G. J. Klomp at La Grande, Oregon, found that 2 and 3 pounds per acre of amitrole gave excellent niggerhead control. This control is somewhat better than that obtained with 2,4-D which previously has given satisfactory control.

In Nebraska, D. L. Linscott and M. K. McCarty showed the movement of radioactive, 2,4-D in ironweed (Veronia baldwinii) apparently was related to net carbohydrate movement with no translocation into roots, rhizomes, or under-

ground buds until a period when carbohydrates were being restored to roots. The carboxyl-tagged 2,4-D was applied to ironweed plants in the field at varying stages of growth from soon after emergence to full bloom. Carbon 14 accumulation was recorded by autoradiographic techniques.

Growth measurements on numbers of individual ironweed plants in the plots that had (1) no treatment, (2) early mowing and late mowing showed 55 to 60 per cent more growth stature on ironweed in the untreated plots than on either early or late mowing plots. Growth differences were correlated with the total available carbohydrates in the ironweed roots. Few differences in plant height could be demonstrated due to grazing management.

Analyses of root samples of ironweed calculated on a per gram basis indicate only minor differences between treatments of the various fractions of carbohydrate material. Where uniform volumes of soil under the plants were sampled, definite differences in volume of roots were noted by treatments. This was a combination of both size and number of roots with the check plots showing at least twice as much root volume as either mowing treatment. Total carbohydrate quantity in the roots was correlated with the rate of plant growth in the different treatments. The major material stored in ironweed is considered to be a fructosan and not starch.

W. C. Robocker, Pullman, Washington, found that control of Bromus tectorum in Agropyron intermedium with 4 pound per acre of isopropyl N-phenylcarbamate (IPC) applied in February 1958 resulted in a residual control of 95 percent in 1959. Monuron at 4 pound per acre had a residual control of 100 percent with some injury to the Agropyron. Seed yields were 18 pounds per acre on plots of the check, 25 pounds per acre on IPC plots and 206 pounds per acre on monuron plots; forage yields were 1150 pounds per acre on check, 1600 pounds per acre on IPC and 3350 pounds per acre on monuron plots. Neither chemical caused decrease in germination or damage to seedlings in seed harvested from the plots.

Treatments of 8 pounds per acre of 2,3,6-TBA and 2 pounds per acre of silvex appeared to be effective against Lathyrus sylvestris one year after treatment. However, neither herbicide prevented growth of new seedlings.

Silvex at 2 pounds per acre reduced Swainsona salsula 85 percent on an early bloom application without cultural treatment.

FORAGE AND RANGE RESEARCH BRANCH

CROPS RESEARCH DIVISION

AGRICULTURAL RESEARCH SERVICE

Title: PASTURE AND RANGE INVESTIGATIONS UNDER ARID, SEMIARID, AND SUBHUMID CONDITIONS (INCLUDING SILAGE AND HAY PRODUCTION)

All of the work reported herein is cooperative with the various State Agricultural Experiment Stations concerned; and certain phases are cooperative with the Animal Husbandry Research Division and the Soil and Water Conservation Research Division of the Agricultural Research Service and with the Forest Service, Bureau of Land Management, and Bureau of Indian Affairs.

This is a highly abbreviated report and covers only a small part of the total program in progress by the above Agency under this Work Project title. A list of the research personnel participating in this work project and their addresses is appended. Numbers in parenthesis following names refer to the numbered paragraphs of this report, to identify each paragraph with the appropriate scientist(s). Work is reported upon only when significant conclusions have been reached, and never in two succeeding years, unless significant additional progress has been made. Therefore, representation of any particular scientist in this report, or failure to be represented, is not necessarily an indication of his productiveness. Some of the scientists not represented in the present report, will appear in reports of the respective states with whom they are cooperating closely.

Progress: 1. Ladino has higher yield potential under irrigation but birdsfoot trefoil roots deeper: Both the percent ground covered and the yield of Ladino clover increased as the level of soil moisture improved, while birdsfoot trefoil decreased and yields were unaffected in studies at Bozeman, Montana. As moisture ranged from no irrigation to low, medium, and high irrigation levels, percent ground cover of Ladino was 56, 73, 87 and 90, respectively, and yields .60, 1.77, 2.83, and 3.42 tons per acre, respectively. With the same moisture range birdsfoot trefoil ground cover was 78, 69, 61 and 46, respectively, with yields unaffected, averaging 2.28 tons per acre. Failure of birdsfoot trefoil to respond to irrigation levels indicated it had access to a water table three or four feet below the surface, beyond the reach of Ladino clover. With additions of nitrogen ranging from zero to 400 pounds per acre, percent ground cover of both species decreased from 82 to 50%, and weeds increased.

2. Perennials superior to annuals or mixtures on cleared chaparral land: At 2200 feet elevation on the Mendocino Forest in California perennial grasses yield 3 to 8 times as much as annuals and nearly twice a perennial-annual mixture. Seven perennial grasses, two annuals and one annual legume were sown in the fall of 1956 on a controlled burn. 1959 dry matter yields of perennial grass alone, and in mixture with annuals, in pounds per acre

were as follows: Smilgrass 3474 and 1907; nodding needlegrass 2264 and 1344; harding grass 1739 and 1113; intermediate wheatgrass 1518 and 896; and tall fescue 688 and 1064. A mixture of annuals alone yielded 702 pounds per acre. The annual mixture consisted of bando brome, domestic ryegrass and rose clover.

3. Nordan crested wheatgrass superior on arid range: On Montana rangeland receiving less than 10 inches annual precipitation Nordan crested wheatgrass was superior to standard crested wheatgrass or Russian wildrye; the yields being 1167, 933, and 892 pounds herbage, respectively. In the 10-12 inch zone Nordan was also best. In the 12-15 inch zone standard and Nordan were about alike with yields of 2500 and 2475, respectively. Intermediate wheatgrass was next with 2212 pounds. At 15-18 inches Nordan yielded 3833, standard 3466, intermediate wheatgrass 2116, smooth brome 1833 and meadow brome 1575 pounds per acre. In a 19-inch zone at 7500 feet elevation, intermediate wheatgrass yielded 4300, Nordan 3933 and smooth brome 3367 pounds per acre. The excellent yields of Nordan are evidence that it is widely adapted in Montana and its performance at 7500 feet elevation suggests a wider elevational range than has been characteristic of standard crested wheatgrass.
4. Depleted mountain sites a challenge to reseeding: Numerous local depleted sites in the National Forests that have defied conventional methods of revegetation are responding to a six-location attack, but findings emphasize the complexity of the problem. In southern Idaho where tarweed dominates depleted sites, stands are obtained of intermediate, pubescent or slender wheatgrasses following control of tarweed either by cultivation or spraying, but frost heaving causes heavy winter mortality to the seeded species. In southern Idaho and central Utah soil hardness, which develops rapidly after spring snow melts, has all but precluded spring emergence of fall seedings. Relative hardness in southern Idaho tests revealed that on areas with a dry surface one week after disappearance of snow, 315 pounds pressure was required to penetrate the soil one inch with a blunt 1-square-inch rod. On surface-moist areas 39 pounds were required. In August, when the soil was very dry 355 pounds were required. In Montana smooth brome and meadow foxtail have been most effective of five species tested on depleted sites. A south exposure was least successful (14 and 15% stands, respectively) and north exposures best (80 and 65% stands, respectively). One year's experience with a straw mulch of native grasses containing ripe seed has given promising results in Montana and northern Idaho. In Nevada at Galina Creek, soil is a critical factor. Only .7 seedlings were obtained per foot of row in Galina Creek soil, while in valley soil, transported to the site, 9.6 were obtained. Micro-nutrient analysis of soil revealed no deficiencies. In central Utah a sawdust mulch, after elimination of competing vegetation, has yielded good stands. In eastern Oregon, competition from tarweed and intense frost heaving constitute the major problems.

5. Harvest frequency and fertilizer affect yield and quality of irrigated bromegrass: Harvesting at hay stage yielded more forage, protein and phosphorus than at pasture stage (twice the harvests) in studies at Upham, North Dakota. Hay yields exceeded pasture yields by 29%. The protein was 12.75% in hay and 17.31% in pasture, and the phosphorus .270 and .339%. The net result was 587 pounds N in harvested hay and 568 in pasture, with 28.4 pounds P_{2O_5} in hay and 25.4 pounds in pasture. Unfertilized pasture contained 14.88% protein while that receiving 200 pounds N per acre contained 20.00%. Phosphorus percentage of pasture herbage was unaltered by N fertilization. Under the hay harvest unfertilized plots contained .302% phosphorus while those receiving 200 pounds N dropped to .273%. Six pounds per acre P_{2O_5} were removed in the unfertilized hay and 22.1 pounds in that receiving 200 pounds N. Application of 200 pounds P_{2O_5} per acre increased the phosphorus from .251 to .320% but had no effect on protein. Phosphorus increased from .264 to .325% as a response to irrigation.
6. Nitrogen increases yield and modifies composition of mountain meadows: Besides markedly increasing yields, nitrogen fertilizer stimulates growth of grasses at the expense of legumes and the rush-sedge component. Studies during 6 years on the Harney Meadow at Burns, Oregon, have established significant yield increases for N at 50 to 200 pounds per acre. Yields in 1959 ranged from 30 to 12.5 pounds hay per pound nitrogen applied. Grass component of the hay was 6% without N and 15% with 200 pounds per acre. Clover decreased from 5 to 1% and the rush-sedge component from 60 to 40%. In companion studies with 0, 200, 400, and 600 pounds N per acre the grass component stabilized, after the second year at 20, 44, 88, and 97% of the hay, respectively. The rush-sedge component, under the same treatment, stabilized at 62, 54, 12, and 4%, respectively. Hay yields were 2.82, 4.27, 4.60, and 4.70 tons per acre, respectively. When supplemental irrigation was applied after haying, nitrogen stimulated re-growth, but yielded only 9.6 pounds additional herbage per pound N.
7. Utilization of tobosa grass adds stability to ranching in Southwest: Full utilization of tobosa was obtained economically by harvesting when green and feeding later, or by spraying with molasses when dry to foster heavier grazing use, in studies on the Jornada Experimental Range in southern New Mexico. Productive sites yielding one ton dry hay per acre were mowed and baled at a cost of \$4.16 per ton. This hay was readily eaten by feeder cattle in the winter season. Grazing utilization in February was 26.1% on untreated grass, but increased to 73.6% on grass sprayed with one part molasses to four parts water. On a site yielding 1-1/4 tons dry forage per acre the cost of spraying was \$10.52 per acre or \$11.44 per ton of hay consumed.

8. Annual range responds to fertilization in a dry year: In the dry 1959 season winter annual range forage in California was ready to graze earlier, and yielded more when given N fertilizer, with further increases in yield from phosphorus and sulfur. Fifty or 100 pounds of N advanced range readiness three weeks, and 150 or 200 pounds N five weeks in studies at the San Joaquin Range in California. The unfertilized range yielded 1100 pounds forage. With 100 pounds N yields increased to 2000 pounds, and with 200 pounds N plus 200 pounds P₂O₅, plus 60 pounds sulfur the yield was 2600 pounds. Herbage on plots receiving 200 pounds N had a protein content of 12.18% compared with 8.25% from unfertilized plots. Additional benefits of dry-season fertilization are expected in carry-over to the next season. In 1959 the growing season precipitation was 8.84 inches compared with 19.4 inches in an average season.
9. 2,4-D renovates pastures infested with fringed sage: Old crested wheat-grass pastures infested with fringed sage yielded increases in grass of 60 to 96% when sage was killed with 2,4-D. A 26-year-old pasture at Mandan, North Dakota, that had been sprayed in June 1958, produced 1604 pounds grass per acre on sprayed plots and 1004 pounds on the unsprayed plots in 1959. Nineteen percent of the vegetation on unsprayed plots was fringed sage. In the same pasture 24 fertilizer plots were split to determine effect of sage control. The sprayed side yielded an average of 1210 pounds grass and the unsprayed 618 pounds. On the unsprayed side 11% of the vegetation was sage in fertilized plots and 21% in non-fertilized plots.
10. Nitrogen increases yields 3 years on Arizona range pasture: A single application of ammonium sulfate in November 1956 significantly increased yields of an established stand of intermediate wheatgrass in 1957, 1958 and 1959. Sixty-six pounds nitrogen returned a three-year total of 2179 pounds more oven-dry herbage than the no-nitrogen treatment. Percentage increase by years was 128, 58 and 39, respectively. In 1957 crude protein in late May (herbage 6 inches high) was 13.70% in unfertilized, and 15.88% in fertilized grass, and by late July (soft dough stage) 5.24% in unfertilized, and 5.88% in fertilized grass. Phosphorus content was increased by the nitrogen application, at the 6-inch stage, from .305% to .341% but at the soft dough stage decreased from .253 to .198%. A parallel application of 33 pounds N in 1956 gave intermediate values. A 99-pound application increased herbage 401 pounds per acre (3-year total) over the 66-pound application, with protein at the two stages 17.68 and 6.78%, respectively. Applications of 32 and 64 pounds per acre P₂O₅ were relatively ineffective. The study area is at 7300 feet elevation with an average annual precipitation of 22.5 inches.

11. Legumes respond to phosphorus and temperature: Four introduced and four native legumes in growth chambers produced 2.8 times as much forage at 70°F as at 50°F in studies at Davis, California. At 50°F, 400 pounds per acre P₂O₅ caused a 5.6-fold increase (over no P₂O₅), at 60° it was a 4.7-fold increase and at 70° a 2-fold increase. Introduced legumes were more sensitive to temperature and P₂O₅, yields increasing 302% from 50 to 70°F and 281% from 400 pounds P₂O₅. Comparable values for native legumes are 253 and 253%. At 50°F and zero P₂O₅ roots constituted 48% of the total growth (.91 to 1.) but at 60°F and 400 pounds P₂O₅ roots were only 27% (.37 to 1.). These data help to explain poor clover years (low temperature) and emphasize the role of P₂O₅ in minimizing their effect on yield. The legumes were (native) Trifolium tridentatum, T. variegatum, T. microcephalum, and Lotus americanus, and (introduced) T. hirtum, T. incarnatum, T. subterraneum and Medicago hispida.
12. Halogeton and tarweed inhibit germination of grasses: Dry plants of halogeton and tarweed, when soaked in water, release substances into solution that materially reduce germination of range grasses. In Nevada studies, ground halogeton mulches of 1 and 3 inches were leached over soil for 1 to 4 months. Time proved not to be a factor, but the deeper mulch was more toxic. Germination in soil leached with 1 inch and 3 inches respectively ranged from 95.2 and 55.4% for Agropyron elongatum, the most tolerant species, to 31.4 and 1.9% for A. sibiricum, perhaps the least tolerant. Elymus junceus with 92.1 and 22.3%, and A. desertorum with 93.8 and 14.7% followed A. elongatum in tolerance. Because of many similarities, this difference between A. desertorum and A. sibiricum is of considerable interest. While the 1-inch and 3-inch mulch of ground halogeton is comparable to 13.5 and 47.5 tons dry matter per acre, respectively, these rates are not excessive if the toxic principle accumulates in the soil over the years, as is believed. In Utah, germination of Agropyron intermedium was reduced from above 90% (control) to 63% with tarweed leachings and 50% with ground tarweed unleached. These data indicate that the competitive action of tarweed and halogeton is more than sharing the available water supply.
13. Burning under proper conditions may control medusahead: Field conditions for burning vary greatly, but the right combination of moisture in seed and fuel, air temperature and humidity, wind movement, and direction of burning, can yield high mortality to medusahead seeds. Studies at Davis, California, revealed that seeds of medusahead may contain as much as 30% moisture when the rest of the plant is as low as 6% and capable of effective burning. Slow moving fires, burning into a wind, maintain heat at any point longer, and are more damaging to seeds. During one week in August at the study site at 7:00 a.m. average temperature was 60°F, relative humidity at 87%, wind velocity 3 miles per hour, and fuel moisture content 11.3%. During the same period at 1:00 p.m. the respective values were 99°, 23%, 11 miles per hour and 3.5%. At 7:30 p.m. on the same days respective values averaged 83°, 39%, 13 miles per hour, and 3.5%. Slow burns left seed with a 16.8% germination and fast burns with 26.9%. Late afternoon was considered the best time to burn. Seeds having a 90% germination and containing 15.4% moisture were exposed to 392°F for 2 minutes in laboratory tests. Seeds so treated all failed to germinate.

14. California ranges respond differently to ryegrass and vetch: Variability characterized the analysis of 9 range soils as judged by the growth made by Lolium multiflorum and Vicia dasycarpa when grown under 6 and 7 fertility treatments, respectively. In a greenhouse study in three replications, using ryegrass, all soils responded significantly to N_2P_2 (subscripts denote hundreds of pounds per acre), three responding also to N_3P_3 . In six soils sulfur became the absolute limiting factor at N_2P_2 . Seven soils responded significantly to sulfur. One soil responded to Molybdenum and none to potassium. Four soils, given N,P,K,S, and M_o , still yielded less than 75 percent of the best soil, suggesting deficiencies in essential elements not studied. Vetch responded significantly to phosphorus and to Molybdenum over the P treatment. Two treatments that included nitrogen produced more than the no-nitrogen treatment. One soil responded significantly only to Molybdenum.
15. Grazing intensity markedly affects soil temperature: Soil temperatures remain cooler throughout the day on protected than on moderately grazed range and are highest on heavily grazed ranges of the Northern Great Plains. On heavily grazed range, June 8 to July 20 maximum soil temperature at one inch below the surface averaged $10.4^{\circ}F$ above maximum air temperature at 4 feet and minimum soil temperature averaged $7.0^{\circ}F$ above minimum air temperature. On protected range maximum soil temperature averaged $6.1^{\circ}F$ below maximum air temperature and minimum soil temperature $5.1^{\circ}F$ above minimum air temperature. Maximum soil temperature on heavily grazed range was 16.5° higher than on protected, while minimum for heavily grazed was only 1.9° higher. Though air temperatures never exceeded $95^{\circ}F$, on heavily grazed range soil temperature at 1 inch exceeded $100^{\circ}F$ on 4 days. On protected range maximum soil temperature reached $80-85^{\circ}$ on 5 days. From July 20 to August 31 the maximum soil temperature on heavily grazed range exceeded that on moderately grazed range by an average of $10.1^{\circ}F$. The temperature difference may possibly explain why heavy range use favors domination of warm season species.
16. Nitrogen fertilizer increases protein of seeded or native range grasses: Application of 40 or 80 pounds N per acre to native range at Mandan, North Dakota, increased protein content of the grass at all seasons, compared to forage from non-fertilized plots. Forty pounds of N was more effective than an associated legume in increasing protein in crested wheatgrass. At the beginning of grazing on native range protein content was 13.9% for the control, 18.7% for 40 pounds N, and 21.1% for 80 pounds N, applied the fall before. On July 30 these values were 8.0, 9.5, and 10.3%, respectively, and at the close of grazing September 8 they were 6.5, 8.4, and 9.9%, respectively. Protein content of crested wheatgrass, given the same treatments, by May 15 was 12.5, 17.8, and 20.8%, respectively. When grazing ended on crested wheatgrass on June 10, these values were 11.8, 13.9, and 16.1%, respectively.

17. Technique developed for removing soil from grass roots by "flotation": A new system for washing the soil from plant roots which is rapid and at the same time saves the entire root system employs for each unit a stream of water in a 5-gallon can. The overflow carries away the fine soil particles in suspension while coarse particles and rocks settle to the bottom. The sample is washed after soaking 15 minutes or more in water, and the job is completed when the overflow water runs clear. One man can manage a battery of units, each one requiring as much as 15 minutes washing time per sample, depending on the amount of clay in the soil, the volume of soil involved, and on how thoroughly the soil had been soaked before washing began.
18. Range forage predictable from precipitation data: Applying a median value to the effective precipitation of a median year, based on as many years precipitation data as are available, provides a basis for accurate estimation of current seasons' production on the high desert of eastern Oregon, and the method can be widely adapted. The effective precipitation falls from October 1 to June 30. The median year represents a 100% or average herbage yield, and departures from it fall on a line originating at zero precipitation - zero yield, connecting with 100% yield for a median year, and above 9 inches precipitation (because the relationship is not linear) increasing the slope of the line by 1.4 times its slope below 9 inches rainfall. The method, which will be refined with experience, capitalizes on a limited amount of yield data by taking full advantage of more extensive precipitation data.

Total Research Personnel and Addresses, and Identification of Each
Scientist With Numbered Paragraphs of Work Project Annual Report

Fred N. Ares (7) P. O. Box 671, Las Cruces, New Mexico

R. E. Bement, G. E. Klipple and Lynn O. Hylton, Room 272 South Hall, Colorado
State University, Fort Collins, Colorado

Alvin T. Bleak (4) P. O. Box 278, Great Basin Research Center, Ephraim, Utah

Clee S. Cooper (1) Room 213, Agricultural Building, Montana State College,
Bozeman, Montana

Donald R. Cornelius (2)(14) P. O. Box 245, Berkeley 1, California

Richard E. Eckert (4)(12) Agricultural Experiment Station, University of
Nevada, Reno, Nevada

Dillard H. Gates (4) Box 268, College Station, Pullman, Washington

Fred B. Gomm (3)(4) Montana Agricultural Experiment Station, Bozeman, Montana

Carlton H. Herbel - P. O. Box 671, Las Cruces, New Mexico

Walter R. Houston - U. S. Range Livestock Experiment Station, Miles City,
Montana

A. C. Hull, Jr. (4)(12) Utah State University, Logan, Utah

Donald N. Hyder and Forrest A. Sneva (18) P. O. Box 833, Burns, Oregon

Gerard J. Klomp (4) P. O. Box 778, La Grande, Oregon

Fred Lavin (10) P. O. Box 631, Mesa, Arizona

William J. McGinnies - Room 272, South Hall, Colorado State University, Fort
Collins, Colorado

E. H. McIlvain and Marvin C. Shoop - U. S. Southern Great Plains Field
Station, Woodward, Oklahoma

Cyrus M. McKell and Alma M. Wilson (8)(11)(13)(17) University of California,
Davis, California

George A. Rogler and R. J. Lorenz (5)(9)(15)(16) P. O. Box 203, Mandan,
North Dakota

Charles B. Rumburg (6) Squaw Butte-Harney Experiment Station, P. O. Box 833,
Burns, Oregon

WESTERN SOIL AND WATER MANAGEMENT RESEARCH BRANCH

SOIL AND WATER CONSERVATION RESEARCH DIVISION

AGRICULTURAL RESEARCH SERVICE

Title: THE EFFICIENCY OF BROADCAST VERSUS DRILLED SUPERPHOSPHATE ON
THE NUTRIENT UPTAKE BY AN ESTABLISHED STAND OF CRESTED WHEATGRASS

Leaders: H. R. Cospers, Newell Irrigation and Dryland Field Station,
Newell, South Dakota, Agricultural Research Service

Objectives: 1. To determine the phosphorus uptake efficiency of broadcast
versus drilled superphosphate by an established stand of crested wheatgrass.

2. To determine nitrogen use efficiency as effected by the two
methods of phosphorus fertilizer application.

3. To compare the effect of broadcasting versus drilling of
superphosphate on root disturbance, and the subsequent re-establishment or
lack of re-establishment of crested wheatgrass.

Progress: This study was established in the fall of 1959. When nitrogen of
phosphorus fertilizer is drilled into established stands of grass considerable
root disturbance results. This is particularly noticeable on those grasses
which grow in clumps. The major emphasis of this study will be to determine
the feasibility of broadcasting phosphorus fertilizer and the subsequent up-
take of phosphorus as compared to drilling the fertilizer. Data measurements
will be made for a period of three years. Fertilizer will be applied the
first year only.

Title: EFFECT OF FERTILIZER ON THE YIELD AND NUTRITIONAL VALUE OF NATIVE
GRASSES UNDER A WATER SPREADING SYSTEM

Leaders: H. R. Cospers, Agricultural Research Service, Newell Irrigation
and Dryland Field Station, Newell, South Dakota, Louis E.
Eberlein, Soil Conservation Service, Rapid City, South Dakota

Objectives: 1. To determine effects of different fertilizer elements alone
and in combination on hay yields and chemical composition of native grasses.

2. To determine the residual effect of applied fertilizers.

3. To study the interaction between soil moisture and effect
of fertilizers on yields and nutritive value of the hay.

Progress: This study was initiated in the fall of 1956. A summary of information obtained from three years of fertilization outside the water spreading system and two years under the water spreading system is available. The soil texture was a clay loam.

Forage yields obtained outside the water spreading system for a three-year period were linearly related to the level of nitrogen for each year fertilizer was applied. Phosphorus fertilizer applied alone had little effect on forage yields. There was no significant interaction between nitrogen and phosphorus fertilizer on forage yields.

Forage yields under the water spreading system were linearly related to the level of nitrogen applied each year. Phosphorus fertilizer applied alone or in combination with nitrogen had little effect toward increasing forage yields.

The nitrogen content of the harvested forage was directly related to the amount of nitrogen applied above the water spreading system and also in the water spreading system. Significant increases in nitrogen content of the harvested forage was obtained in both systems each year nitrogen fertilizer was applied. The application of phosphorus fertilizer significantly increased the phosphorus content of the forage in any year applied in both systems.

The residual effects of applied nitrogen on nitrogen content of the forage was evident the second year after application from both systems but only for the 80 and 160 pounds per acre rates. A residual effect from applied phosphorus on the phosphorus content of the forage was obtained three years after application outside the water spreading system and two years after application in the water spreading system. The application of nitrogen without phosphorus had a tendency to produce forage lower in phosphorus content in both systems.

As the soil moisture outside the water spreading system decreased from a wet to a dry year the nitrogen and phosphorus content of the forage decreased. The use of a water spreading system significantly increased forage yields in comparison to dryland range forage yields. When fertilizer was applied to both systems the forage harvested from the water spreading contained more phosphorus but less nitrogen than forage produced from corresponding rates of nitrogen and phosphorus on the dryland system. The yields of nitrogen and phosphorus obtained from total forage yields was much larger from the water spreading system because of the higher forage yields as compared to the forage yields on the dryland system. The use of fertilizer increased moisture use on the dryland range by approximately 60 percent but doubled the moisture use in water spreading system.

Title: EFFECT OF FERTILIZATION ON THE YIELD AND NUTRITIVE VALUE OF
NATIVE GRASSES UNDER DRYLAND CONDITIONS OF WESTERN SOUTH
DAKOTA AND EASTERN WYOMING

Leaders: H. R. Cosper, Newell Irrigation and Dryland Field Station,
Newell, South Dakota, Agricultural Research Service;
James C. Larsen, Soil Conservation Service, Sundance, Wyoming

Objectives: 1. To determine effects of different fertilizer elements alone and in combination on yield and chemical composition of native grasses and to study interaction between chemical characteristics of soils and effects of fertilizers.

2. To study effects of fertilization practices on botanical composition of native grass range.

3. To determine most effective time of fertilizer application.

Progress: This study was established in the fall of 1957. A summary of findings for two year's data is available. The various rates of nitrogen and phosphorus fertilizers were applied at three periods of the year on this native range site with a silt loam soil texture. The periods of application were fall, spring and summer. Information was obtained for the first year after the fertilizer was applied and for the residual benefits the second year.

Significant increases in total forage production were obtained for two years from the application of nitrogen fertilizer. Phosphorus when applied with nitrogen the first year produced significant increases in forage production but did not the second year after application. The interaction of nitrogen and phosphorus fertilizer was not significant in either year.

Significant increases in the nitrogen content of the harvested forage was obtained by the use of nitrogen fertilizer. The addition of phosphorus fertilizer alone had no significant effect on nitrogen content of the harvested forage but tended to produce forage lower in nitrogen content both years.

The application of phosphorus fertilizer alone or in combination with nitrogen when applied in the spring or summer significantly increased the percent phosphorus of the harvested forage the first year. No significant increase in phosphorus content of the forage was obtained when the phosphorus fertilizer was applied in the fall. Significant increases in the phosphorus content of the forage was not obtained the second year following the application of phosphorus fertilizer.

The nitrogen and phosphorus content of the harvested forage decreased with a decrease in available soil moisture. The use of fertilizer however increased the moisture use efficiency of the available soil moisture by as much as three times that of the untreated check treatment.

The botanical composition of this native range was affected by the use of nitrogen and phosphorus fertilizer. The major increase in forage yields from the application of fertilizer was attributed to the non-grasses. The greatest total production for the two-year period was obtained when the fertilizer was applied in the fall at the rate of 160 pounds of nitrogen and 160 pounds of phosphorus per acre.

Title: EFFECT OF NITROGEN FERTILIZER ON THE USE OF WATER AND GROWTH OF BUFFALO GRASS

Leaders: C. E. Johnson, Central Great Plains Field Station, Akron, Colorado, Agricultural Research Service. Cooperating with Colorado Agricultural Experiment Station

Objectives: 1. To determine the effect on yield per acre, protein yield per acre, and water use per acre on Buffalo Grass under nitrogen fertilization.

2. To determine if nitrogen applications will economically increase the efficiency of moisture use in the production of Buffalo Grass under dryland conditions.

3. To determine if the quantity of the forage can be extended over a period of years.

Progress: This experiment was initiated in 1958. Nitrogen applications are at the rate of 0-40-80-160 and 200 lbs. of available nitrogen per acre in split plot design to study residual nitrogen effects.

Dry matter yield and crude protein yield has increased 100% on the 40 lb. of N application over no nitrogen in both 1958 and 1959. (Table 1). Crude protein yield per acre has increased 200% over no treatment on the 80 lbs. of N treatment. Dry matter production leveled off at the 80 lb. of N treatment in 1959 but continued to increase at higher nitrogen treatments in 1958, a year of higher rainfall. Most encouraging has been the residual effect or continued increases in both dry matter and crude protein yields in 1959.

The experiment will continue for at least three more seasons to study residual effects as well as continued nitrogen treatments.

Table 1. -- Dry matter and crude protein yield as influenced by nitrogen application

	Nitrogen rate - (lbs. per acre)				
	0	40	80	160	200
Dry Matter-1958	1045	2015	1909	2351	2138
Crude Protein-1958	60	131	188	273	268
Dry Matter-1959*	368	902	865	902	886
Crude Protein-1959*	29	105	117	104	99
Dry Matter, Residual Plots-1959**	480	934	1046	537	630
Crude Protein, Residual Plots-1959**	43	78	123	71	81

* Retreated N applied both 1958 and 1959.

** N applied 1958 only.

Title: FORAGE PRODUCTION POTENTIAL OF BLUE GRAMA (BOUTELOUA GRACILIS) AND SUDAN (SORGHUM SUDANENSE) WITH ADEQUATE WATER AND NITROGEN

Leaders: O. R. Lehman, J. J. Bond, J. F. Cherry, Agricultural Research Service, SWCRD, Bushland, Texas. Cooperating with George F. Ellis, Jr., Texas Agricultural Experiment Station

Objectives: To determine the effect of adequate soil moisture and nitrogen on forage production and nitrogen uptake by native blue grama and by annual sudan.

Progress: The first year's results show that on Pullman silty clay loam and with adequate soil moisture throughout the growing season, blue grama and sudan responded to various rates of nitrogen as follows:

Treatment	Total seasonal drymatter production	Water use efficiency	Total nitrogen uptake
<u>Lb. N/acre</u>	<u>Lbs./acre</u>	<u>Lbs./inch</u>	<u>Lbs./acre</u>
Blue grama			
0	1268	31	16
200	3936	92	65
400	6051	140	123
Sudan			
0	5115	219	77
200	9532	393	180
400	10228	403	235

The results may be briefly summarized:

(1) Applied nitrogen materially increased dry matter yields of both blue grama and sudan. Dry matter yields of sudan were much greater than those of blue grama.

(2) Pounds of dry matter produced per inch of water use was greater with sudan than with blue grama. Applied nitrogen greatly increased the water use efficiencies.

(3) Total nitrogen uptake was greater with sudan than with blue grama. Sudan was almost twice as efficient as blue grama in utilizing applied nitrogen.

Future Plans: The results stress that blue grama is very inefficient in utilizing soil moisture and nitrogen. A similar evaluation of selected introduced species and improved native grasses is planned for the future.

Title: FERTILITY EXPERIMENTS ON NATIVE ANNUAL RANGE

Leaders: Ralph E. Luebs, Agricultural Research Service, Soil and Water Conservation Research Division; Arthur E. Laag, University of California, Riverside, California

Objectives: To determine the nitrogen fertilizer requirements for optimum production of native annual range plants.

Progress: Investigations are conducted in southwestern Riverside County, California, at an elevation of about 2,000 feet in the coastal range. An average annual rainfall of 25 inches is representative for this particular area.

Enclosed plots in the experimental pasture area have been used to compare several rates of nitrogen applied as ammonium sulfate. Very few leguminous plants are present and no yield response to sulfur has been obtained during the current season. During a season of high rainfall and a long growing period, early forage growth responded markedly to nitrogen fertilizer. Dry matter yield increases of 90 percent were obtained from rates equivalent to 80 pounds of nitrogen per acre. Differences in yields of forage clipped only at the end of the season were not significant. With low rainfall and a short growing season, significant increases (50 percent) in forage production from nitrogen application were measured with a single clipping at the close of the season.

One phase of these investigations has been a comparison of adjacent fertilized and nonfertilized pastures with respect to beef gains. Pastures were grazed during the green forage season, which may extend from December to May, but is frequently much shorter, depending on the rainfall. Ammonium sulfate was broadcast. The following table summarizes results.

Season	Rainfall (in.)	Length of growing season	Lb. N/A Applied	Total pounds beef gain/A	
				Fertilized	Nonfertilized
1957-58	38.77	142 days	60	106	57
1958-59	14.02	62 days	80	61	44

Future plans include further nutrient deficiency investigations and a study of the relations of botanical composition to available nutrients and to moisture.

Title: INFILTRATION STUDIES ON SOILS WITH VARYING AMOUNTS AND KINDS OF COVER

Leader: Frank Rauzi, Agricultural Research Service, Laramie, Wyoming

Objectives: 1. To determine the effect of different kinds and amounts of pasture grass cover on the ability of a soil to take up water in the form of simulated rainfall.

2. To obtain a relative water-intake rating for major soil types under varying cover conditions.

Progress: During 1959, water-intake studies were conducted on rangelands in Wyoming, Montana, and Kansas. Data were obtained by sampling contrasts in range cover conditions along fence lines on comparable soils.

Generally, it was found that water-intake rates during the second 30-minute period of the 1-hour test was twice as great on the rangelands rated good or excellent than on those rated poor or fair in the 10-to 14-inch rainfall belt.

Near Rosalia, Kansas, water-intake rates on non-burned and lightly grazed areas were significantly higher than on spring-burned lightly grazed areas during the first 15-minute period of the 1-hour test.

Title: ANNUAL PASTURES FOR WYOMING DRYLAND

Leaders: Frank Rauzi, Agricultural Research Service. Cooperating with Robert L. Lang, Department of Range Management, University of Wyoming

Objectives: 1. To determine the feasibility of annual crops for pasture to supplement native pastures.

2. To determine which of the small grains, annual grass, and annual legumes are best suited for annual pastures in this area.

3. To determine the grazing capacity and animal gains and the best time to graze the annual pastures.

Progress: The combination of three seeded pastures (oats, annual sweet clover, and Sudan) were grazed for a total of 232 sheep days per acre. A total of 28 pounds lamb gain per head or 112 pounds of lamb gain per acre was obtained by grazing the annual pastures for 58 days, beginning June 30.

Title: THE EFFECT OF VARIOUS AMOUNTS AND DATES OF APPLICATION OF NITROGEN FERTILIZERS ON NATIVE SHORTGRASS RANGELAND

Leaders: Frank Rauzi, Agricultural Research Service. Cooperating with Robert L. Lang, Department of Range Management, University of Wyoming and L. I. Painter, Department of Soils, University of Wyoming, Laramie, Wyoming

Objectives: 1. To determine the effect of the amount of nitrogen and dates of application upon yield and protein content of native shortgrasses.

2. To study the effect of amount of nitrogen and date of application upon the vegetative composition and residual effect.

3. To study treatment effect upon range utilization by livestock at the Archer Substation.

Progress: Precipitation during the growing season at both Archer and Gillette, Substations, was considerably below average during 1959. Thus, the data reflects the arid condition during the 1959 growing season.

At the Gillette Substation forage production from the treated plots all showed an increase over the check plot. The greatest increase in forage yield was from the plots treated in May, 1959, with 66 lbs. N per acre. This increase was 221 percent of the check plot.

At the Archer Substation forage production from the plots varied from 102 to 227 percent of the check plot. By analysis of variance, it was found that only the plots treated in May each year with 33 or 66 pounds N per acre produced significantly more vegetation than the check plot during 1959.

Title: THE EFFECT OF FERTILIZATION AND CLIPPING TREATMENTS ON MOISTURE USE OF NATIVE RANGE

Leaders: D. E. Smika and H. J. Haas, Soil and Water Crops Research Division, Agricultural Research Service. Cooperating with G. A. Rogler and R. J. Lorenz of the Crops Research Division, Northern Great Plains Field Station, Mandan, North Dakota

Objectives: 1. To determine changes in soil moisture under native sod by monthly intervals throughout the season at 1-foot increments to a depth of 6 feet on plots receiving 7 different fertilizer treatments, 1 clipping frequency and 1 clipping height.

2. To determine the moisture use by 1-foot increments to a depth of 6 feet on native range clipped at 2 heights, 2 frequencies, and fertilized with 3 rates of nitrogen.

Progress: Soil moisture determinations in the course of the study thus far have shown no effect of fertilizer or clipping treatments.

Title: EFFECT OF PLACEMENT OF FERTILIZER ON GROWTH OF GRASS

Leaders: D. E. Smika and H. J. Haas, Soil and Water Conservation Research Division, Agricultural Research Service. Cooperating with G. A. Rogler and R. J. Lorenz of the Crops Research Division, Northern Great Plains Field Station, Mandan, North Dakota

Objectives: 1. To compare the residual effect of broadcast and deep drilled fertilizer on (1) the yield and botanical composition of native grass in a heavily grazed pasture and on (2) the yield of grass in a 25-year-old crested wheatgrass pasture.

2. To determine the effect of chemical spray and fertilizer and their interaction on the control of fringed sage, Artemisia frigida and the subsequent effect on yield of grass in a 25-year-old crested wheatgrass pasture.

Progress: From the results of the study thus far, there appears to be no advantage to placing fertilizer 4-inches deep compared to broadcasting on the surface. However, there is an indication that the cultivation effect of the drill may improve yields.

One spray application of 2,4-D ester was effective in killing the sage. The results carried over into the second year, but it remains to be determined how many years it will be effective.

Title: SOIL MOISTURE USE BY GRAZED NATIVE GRASS AS INFLUENCED BY NITROGEN FERTILIZER

Leaders: D. E. Smika and H. J. Haas, Soil and Water Conservation Research Division, Agricultural Research Service. Cooperating with G. A. Rogler and R. J. Lorenz of the Crops Research Division, Northern Great Plains Field Station, Mandan, North Dakota

Objectives: 1. To determine soil moisture use by native grass as influenced by nitrogen fertilizer.

2. To determine a relation between soil moisture in the fall and the following seasons' cattle gains for each fertilizer treatment.

Progress: During the 2 years of this study no relation of moisture use or soil moisture content to fertilizer treatment has been established.

Title: ANNUAL AND RESIDUAL EFFECTS OF FERTILIZERS ON YIELD AND COMPOSITION OF NATIVE GRASS AT TWO MOISTURE LEVELS

Leaders: D. E. Smika and H. J. Haas, Soil and Water Conservation Research Division, Agricultural Research Service. Cooperating with G. A. Rogler and R. J. Lorenz of the Crops Research Division, Northern Great Plains Field Station, Mandan, North Dakota

Objectives: 1. To determine the interaction of two soil moisture levels in the fall and applications of fertilizer on native grass production and changes in botanical composition.

2. To determine number of years of residual effect from one year's application of fertilizer on native grass production and changes in botanical composition.

3. To determine the effect of annual fall applications of fertilizer on each following year's native grass production and changes in botanical composition.

4. To determine a relationship between amount of moisture available in the fall and amount of fertilizer to apply to increase native grass production.

5. To compare soil moisture use by native grass between various fertilizer rates and treatments.

6. To compare soil moisture use by native grass from two soil moisture levels.

7. To relate growth and moisture use during the season for the various fertilizer treatments on both moisture levels.

Progress: Both fertilizer treatments and moisture levels are effective in increasing native grass yields.

Total seasonal moisture use is unaffected by fertilizer treatments, but the high fertility treatments use moisture at a faster rate during the growing season than do the low fertility treatments.

Moisture use by all fertilizer treatments is somewhat greater on the high moisture level, but all treatments on the high moisture level have a higher moisture use efficiency.

Title: THE EFFECT OF NITROGEN FERTILIZER AND ALFALFA ON THE RELATIONSHIP OF SOIL MOISTURE TO PRODUCTION AND SOIL MOISTURE USE BY GRAZED CRESTED WHEATGRASS

Leaders: D. E. Smika and H. J. Haas, Soil and Water Conservation Research Division, Agricultural Research Service. Cooperating with G. A. Rogler and R. J. Lorenz of the Crops Research Division, Northern Great Plains Field Station, Mandan, North Dakota

Objectives: 1. To determine soil moisture use during the growing season by crested wheatgrass fertilized with 3 rates of nitrogen and a crested wheat-grass-alfalfa mixture under grazing.

2. To determine soil moisture in the pastures in the fall of each year as a possible basis for predicting the following seasons livestock gains.

Progress: During the 2 years of this study the crested wheatgrass-alfalfa pasture has contained the least amount of soil moisture at all samplings. To date, the remaining pastures have had no difference in moisture use.

Title: NITROGEN FERTILIZER USE AND RECOVERY AND TOTAL NITROGEN AND AVAILABLE PHOSPHORUS CONTENT IN NATIVE AND TAME GRASS PASTURE SOILS AS INFLUENCED BY YEARS OF GRAZING, POUNDS OF BEEF REMOVED AND FERTILIZATION

Leaders: D. E. Smika, C. W. Carlson, and H. J. Haas, Soil and Water Conservation Research Division, Agricultural Research Service. Cooperating with G. A. Rogler and R. J. Lorenz of the Crops Research Division, Northern Great Plains Field Station, Mandan, North Dakota

Objectives: 1. To determine the effect of 12 years of different intensities of grazing on the total nitrogen and available phosphorus in the soil.

2. To determine if the difference in pounds of beef removed from adjoining native grass and crested wheatgrass pastures has had any effect on the total nitrogen and available phosphorus in the soil.

3. To determine total soil nitrogen, available soil phosphorus and nitrogen use and recovery in native grass fertilized with nitrogen.

Progress: Total soil nitrogen determinations show: (1) Over the past 12 years total soil nitrogen increased as grazing intensity increased. (2) The difference in pounds of beef removed over a 27-year period from adjacent pastures has had no effect on total soil nitrogen. (3) Total soil nitrogen increased as a result of fertilization. When total soil nitrogen data was combined with nitrogen in the plant material attributed to the fertilizer at least 80% of the applied nitrogen was accounted for.

Title: THE DEPTH OF SOIL MOISTURE WITHDRAWAL BY NATIVE GRASS AS INFLUENCED BY FERTILIZERS

Leaders: D. E. Smika and H. J. Haas, Soil and Water Conservation Research Division, Agricultural Research Service. Cooperating with G. A. Rogler of the Crops Research Division, Northern Great Plains Field Station, Mandan, North Dakota

Objectives: To determine if nitrogen fertilizer applied to native grass will increase the utilization of moisture in the lower depths.

Progress: As this study progressed there was a gradual decrease in moisture content in the lower depths under all treatments. The high nitrogen treatment (90 lbs. N/Acre) reached the wilting point of the soil early, with the other treatments (0 & 30 lbs. N/Acre) gradually approaching this level. Within each of the lower depths soil moisture under all treatments has remained at the wilting point for the past 2 seasons.

Title: EFFECT OF MOISTURE LEVELS AND FERTILITY STATUS ON THE ESTABLISHMENT OF SELECTED GRASS SPECIES

Leaders: N. H. Welch, Agricultural Research Service, SWC; E. B. Hudspeth, Agricultural Research Service, AERD; Earl Burnett, Agricultural Research Service, SWC; and G. L. Randel, Agricultural Research Service, SWC, Big Spring, Texas. Cooperating with the Agricultural Engineering Research Division of the Agricultural Research Service, Texas Agricultural Experiment Station, and Soil Conservation Service

Objectives: 1. To study the effect of moisture and fertility and their interaction on the establishment of selected grass species.

2. To determine the difference in response of grass species to moisture and fertility variables.

3. To determine the moisture conditions necessary for the establishment of these grasses, and to predict their chances of occurrence.

Progress: An increase in seedling vigor and stand establishment has resulted from the use of a nitrogen-phosphorus combination on species with medium and high seedling vigor and in some cases from the use of nitrogen alone. There has been no response to phosphorus when used alone.

No positive response to fertilizer has occurred on species with low seedling vigor; however, slight detrimental effects have been observed.

Rainfall conditions under which these results were obtained have been average or above average. Future plans are to evaluate these factors under more adverse moisture conditions in order to determine the critical moisture level under which fertilizer would be of benefit in grass establishment.

DIVISION OF RANGE MANAGEMENT AND WILDLIFE HABITAT RESEARCH

FOREST SERVICE

Range management research in the Western States is conducted by four regional forest and range experiment stations of the Forest Service located at Portland, Oregon; Berkeley, California; Ogden, Utah; and Fort Collins, Colorado. This research is concerned with improvement and management of forage resources of forests, woodlands, and related nonforest ranges and includes fundamental research to provide a better understanding of characteristics and requirements of vegetation as well as applied studies of grazing management, improvement practices, and their relation to other land uses and values. Much of this research involves cooperation in its planning and conduct with the Agricultural Research Service, Soil Conservation Service, Bureau of Land Management, Bureau of Indian Affairs, Fish and Wildlife Service, colleges and universities, State experiment stations and extension services, fish and game departments, private organizations, and stockmen.

This report includes brief statements of progress for only a few of the studies that are being conducted in each Work Project. The name of the scientist concerned with each study is indicated. A complete list of range research personnel at each station is also included. Although the workers are stationed at various locations within the station territory, communications addressed to the individual at the appropriate station headquarters will reach him promptly.

Pacific Northwest Forest and Range Experiment Station, P. O. Box 4059,
Portland 8, Oregon

David F. Costello, Division Chief
J. Edward Dealy
Richard S. Driscoll
George A. Garrison
Burt R. McConnell
Jon M. Skovlin
Justin G. Smith
Gerald S. Strickler

Pacific Southwest Forest and Range Experiment Station, P. O. Box 245,
Berkeley 1, California

E. Joseph Woolfolk, Division Chief
Lowell Adams
Jay R. Bentley
Don A. Duncan
Charles A. Graham
August L. Hormay
Richard L. Hubbard
Eamor C. Nord
Merton J. Reed
Jack N. Reppert

Intermountain Forest and Range Experiment Station, Forest Service Building,
Ogden, Utah

Weldon O. Shepherd, Division Chief
Joseph V. Basile
Robert B. Ferguson
Neil C. Frischknecht
Kimball T. Harper
Ralph C. Holmgren
Selar S. Hutchings
Odell Julander
James O. Klemmedson
William A. Laycock
Donald W. Lynch
Meredith J. Morris
Walter F. Mueggler
A. Perry Plummer
Jack E. Schmautz
Peter F. Stickney

Rocky Mountain Forest and Range Experiment Station, Forestry Building,
Colorado State University, Fort Collins, Colorado

Elbert H. Reid, Division Chief
Dwight R. Cable
H. L. Gary
George E. Glendening
Wayne C. Hickey
Richard M. Hurd
Donald A. Jameson
Wallace M. Johnson
James O. Keith
S. Clark Martin
Morton May
Lowell G. McEwen
Charles P. Pase
Harold A. Paulsen, Jr.
Floyd W. Pond
Hudson G. Reynolds
Dwight R. Smith
Harry W. Springfield
Ronald D. Tabler
George T. Turner

Title: CHARACTERISTICS AND REQUIREMENTS OF VEGETATION ON FOREST AND RELATED RANGES BASIC TO MANAGEMENT STUDIES AND PRACTICES

Progress: Ecology and Physiology: On summer range in eastern Oregon, annual removal of 40 per cent of the current herbage of elk sedge for a 5-year period resulted in lowered herbage production, and 60 per cent removal resulted in lowered production after 2 years. Effects were most severe from slipping during the first half of the season, prior to seed dissemination. Reductions in size and number of seed stalks were the first signs of lowered vigor. These indicators of range trend could be used effectively as guides for changes in management before permanent damage to the plant and lowered range productivity occur. (Garrison-Driscoll)

Seasonal levels of bitterbrush carbohydrate reserves in Washington varied from 5 to 10 per cent in twigs and from 6 to 15 per cent in roots. These plant food reserves were lowest during periods of active growth and highest during dormancy. (McConnell)

From ecological studies in California, it was determined that desert bitterbrush (Purshia glandulosa) resprouts frequently and abundantly following burning in contrast to antelope bitterbrush (Purshia tridentata), which is often killed by fire. Also, some ecotypes of desert bitterbrush occur on calcareous soils, whereas antelope bitterbrush is found only on non-calcareous soils. (Nord)

Prominence of big sagebrush (Artemisia tridentata) and Utah juniper (Juniperus osteosperma) is often attributed to overgrazing, but these species made up 88 per cent of the plant cover on an isolated plateau in the Grand Canyon, Arizona, that has never been grazed by domestic livestock. Apparently abundance of these species cannot be used indiscriminately as an indicator of range abuse. (Jameson)

Prolonged protection from grazing reduced vigor in old stands of fairway and crested wheatgrasses at the Benmore Experimental Range in Utah. Although herbage yield and seed production increased during the first 2 years, they declined sharply by the fourth year, and even further by the twelfth year of protection. However, such decline is probably more closely related to age of the stand than to protection from grazing and, as shown by previous studies, may be largely caused by parasitic nematodes. (Frischknecht)

In a study of mountain ranges in Montana, both rough fescue (Festuca scabrella) and Idaho fescue (Festuca idahoensis) grassland in good condition supported a ground cover (including litter) of almost 100 per cent. Such grasslands are characterized by a large number of perennial species. Rough fescue is a dominant grass in many openings of the northern forests of Montana from 2500 feet elevation in the northwest part of the state to 9500 feet in the southwest; however, this species has apparently been eliminated or greatly reduced by grazing pressures on many sites within its natural range. (Schmautz)

Forage values: Production and utilization characteristics of the important forage species were determined on two sites grazed by sheep in the Big Horn Mountains of Wyoming. Grass and grasslike species were 1.2 times more abundant than the forbs on the ridge site, but forbs were 1.7 times as abundant as grass and grasslike species on the basin site. On the deeper soils of the basin site, herbage production was 1,041 pounds per acre or 233 pounds more than the ridge sites. Highest herbage producers were Idaho fescue (Festuca idahoensis), avens (Geum triflorum), and silky lupine (Lupinus sericeus). (May)

Title: RANGE MEASUREMENT AND EVALUATION TECHNIQUES FOR FOREST AND RELATED RANGES

Reliable techniques are needed for measuring forage utilization and range condition and trend in order that range management practices may be properly evaluated. Although many advances have been made in this field, no methods have been developed that are wholly satisfactory. Development of improved methodology is therefore an important part of range management and wildlife habitat research.

Progress: Measurement techniques: Different regression equations are necessary to determine sheep and cattle utilization of crested wheatgrass by counting numbers of grazed plants. The equation for utilization by sheep is $Y = 1.101X - 34.14$, in which Y = utilization by weight in per cent and X = per cent of plants grazed. For cattle the equation is $Y = .734X - 2.41$. Cattle and sheep graze about the same number of plants within the range of 55 to 65 per cent utilization, but under lighter use sheep grazed fewer plants more intensively than cattle. The grazed-plant method is also adaptable to pine-bunchgrass ranges, but different regression equations are needed for Arizona fescue (Festuca arizonica), mountain muhly (Muhlenbergia montana), and blue grama (Bouteloua gracilis). (Springfield)

To evaluate merits of the "nearest neighbor," "closest individual," and "point-centered quarter" methods in measuring density and spatial distribution of plants, distance measurements by these methods were compared with plant counts on 33 stands of small desert shrubs in western Utah.

Included were pure stands of winterfat and black sagebrush, and mixed stands of these species with rabbitbrush and/or shadscale. Spatial distribution of plants in pure stands was found to be essentially random and only randomly dispersed stands showed close agreement between methods. In mixed stands individual species often were strongly contagious, but all species combined were randomly dispersed. The ratio, observed/expected mean distance, provides a useful index of plant distribution. This function is asymmetrical: upper limit, infinity; lower limit, approximating 0.75. Index of 1.00 is expected in random populations; lower values indicate regular distribution; higher values indicate contagion. Index values for individual species in stands studies ranged from 0.94 to 3.01. Populations having values between 0.95 and 1.22 were essentially random. (Hutchings - Morris)

Preliminary results on mountain grasslands in Montana indicate that a "per cent production" method yields accurate and consistent estimates of forage production. The double sampling method consists of rating production on sample plots as percentages of that on a clipped base plot. Independent estimates by 4 observers using this procedure were compared with harvested weights, and correlation and regression coefficients were calculated. On highly productive range the estimates of grass production were more consistent than those of forbs, whereas on low-production range the reverse was true. For high production, correlation coefficients of the 4 estimators ranged from .79 to .94 for grasses and .67 to .93 for forbs; under low production coefficients ranged from .42 to .83 for grasses and .74 to .90 for forbs. A major obstacle encountered was the difficulty of recognizing different species of grass and of separating dry current growth from that remaining from the previous year. (Schmautz)

The spherical densiometer, a gridded convex mirror, was tested on the deer habitat study at Silver Lake, Oregon, for the measurement of tall shrub and tree crown intercept above a line transect. By holding the densiometer above the transect tape and extending a plumbob down to the tape, reflected crown overstory can be read directly as intercept on a line transect. (Strickler)

Title: GRAZING MANAGEMENT AND IMPROVEMENT OF FOREST AND RELATED RANGES
 GRAZED BY LIVESTOCK

The main objective of this research is the determination of optimum intensities, seasons, and systems of grazing to obtain maximum production and efficient use of both native and improved livestock range on forest and related areas. Studies of range condition and trend standards and of burning for range improvement are also of major importance.

Progress: Grazing management of native range: On the Manitou Experimental Forest in Colorado, utilization of all major forage species was related to the amount of ponderosa pine overstory. Grassland areas are clearly most preferred by cattle, and dense timber the least. For example, Arizona fescue in the moderately grazed pastures was utilized 54 per cent in grasslands, 30 per cent in open timber, and only 14 per cent in dense timber. As in previous years, heifers gained considerably more under light and moderate than under heavy use. The greatest gains, regardless of grazing intensity, were in June, and the rate of gain decreased progressively as the season advanced. (D. R. Smith)

On the San Joaquin Experimental Range in California, a severe drought caused herbage production to be the lowest ever recorded: 690 pounds of air-dry herbage per acre as compared with the long-time average of 1650 pounds. During the five-month season from April 16 to September 16, 1959, heifers averaged only 119 pounds of gain or .75 pounds per head per day. However, during the first month of the 1960 green season, the average gain was 79 pounds or 2.73 pounds per heifer per day. (Duncan-Reppert)

On heterogeneous ranges of the Blue Mountains in Oregon, a weighted utilization figure of all principal species was found to provide a more reliable estimate of grazing intensity than an evaluation of utilization based on just the key species. Though the key species technique is expedient, it does not always reflect total use of the range. For example, ranges A and B each had 39 per cent average utilization on the key species, bluebunch wheatgrass; but based on total herbage removal, range A was grazed nearly twice as heavily as B. (Garrison)

Grazing management of improved range: Six years of experience with grazing management in the alpine zone in central Utah indicates that conversion of depleted forb land to grass through artificial seeding can help solve several management problems. In addition to increasing forage production, seeding palatable grasses on gentle terrain draws cattle from steep slopes where accumulation of vegetal cover is needed for watershed improvement. Poisonous plant problems are also reduced. In six years, only one loss has resulted from tall larkspur poisoning within the seeded range. This was after an unseasonal heavy snow in September that covered other herbaceous vegetation. In contrast, losses varying from 8 to 15 per cent have occurred on comparable natural range where tall larkspur prevails. (Plummer-Frischknecht)

On the subalpine cattle range of central Utah, about 1 cow month grazing was taken from 2-1/2 to 3 acres of seeded range compared to about 1 cow month to 5 acres of the nonseeded area. Utilization of the exotic seeded grasses (smooth brome, meadow foxtail, orchardgrass, timothy, and tall oatgrass) was slightly less than 50 per cent, whereas use of mountain brome and slender wheatgrass was about 20 per cent. The only native species approaching the introduced grasses in utilization was ovalhead carex, which was utilized to about 45 per cent. With this exception, all native species were used less than 25 per cent. Tall larkspur, prevalent in patches on both converted and natural range was utilized about 13 per cent on the seeded area in contrast to 35 per cent on the natural range. (Plummer-Frischknecht)

On seeded foothill range in the pinyon-juniper zone of Utah, little difference has been detected in the preferences shown by cattle for the most persistent and productive grasses including crested wheatgrass, intermediate wheatgrass, beardless bluebunch wheatgrass, and Russian wildrye during the past 8 years. Crested wheatgrass has been most productive over the years followed by the grasses above in about the order named. Tall wheatgrass and bearded bluebunch wheatgrass have failed to persist in good stands in competition with crested wheatgrass and under the 50 per cent utilization imposed in early May on this shallow soil with its underlying rocky profile. (Plummer-Frischknecht)

In contrast to cattle, sheep on an area adjacent to the pinyon-juniper type have shown a strong preference for Russian wildrye followed in order by intermediate wheatgrass, pubescent wheatgrass, and crested wheatgrass. On this deep clay-loam, only crested wheatgrass and Russian wildrye have maintained satisfactory stands through the 8-year period. Apparently the sandier soil of the pinyon-juniper type, underlain by rocks, is better suited for the growth and persistence of a wider variety of species than the deeper and heavier soils. (Plummer-Frischknecht)

The seeded foothill range has been grazed in early May when about one-half growth is available. At this time all the growth was grazed off, leaving about 1-inch stubble height. The subsequent growth after grazing has resulted in a utilization varying between 40 and 65 per cent, but averaging about 50 per cent. Deer have shown a preference for these plantings in March and April, but in no year has their grazing been noted to take more than 5 per cent of the total growth produced. (Plummer-Frischknecht)

In California, gain per yearling heifer for the 84-day dry season grazing period was 66 pounds on unfertilized native range, 85 pounds on sulfur-fertilized, and 135 pounds on nitrogen-fertilized range. Animals were removed when a moderate degree of herbage utilization was obtained. (Graham)

Increased forage production as a result of spraying mesquite on the Santa Rita Experimental Range in Arizona was sufficient to repay the cost of treatment in 4 years. In 1959, 5 years after initial spraying, herbage production was 833 pounds per acre where mesquite kill was 58 per cent versus 548 pounds per acre in untreated areas. (Martin-Cable)

Following 2 years of spring grazing by cattle to 76 per cent utilization, crested wheatgrass plants at the Manitou Experimental Forest in Colorado increased in number but decreased in size as compared with fall grazing. In 1959 the number of plants per 20-square-foot plot averaged 44 where grazed in the spring but only 35 on fall-grazed areas. Basal area of crested wheatgrass grazed in the spring was only 6.1 per cent compared with 8.6 per cent where grazing was in the fall. (D. R. Smith)

Influencing livestock distribution and supplementing range forage: The need for sound distribution practices was emphasized during the past year of poor forage conditions on the Starkey Experimental Range in eastern Oregon. Techniques that promoted better cattle distribution in past years returned dividends during the droughty season of 1959 when forage production was greatly reduced. Practices such as initially distributing cattle in areas of less dependable stock water took advantage of forage that soon became unusable from lack of water. Salt was withheld from areas near certain permanent water developments until it became evident that cattle were no longer grazing in the areas of failing water. After abundant rains came in mid-September, cattle were moved into unwatered areas. Since cattle need water only every second or third day during cool wet periods, heavier use of unwatered areas was encouraged. Because of the uniform livestock distribution, utilization of principal forage species was only slightly greater than normal in 1959 in spite of adverse conditions. (Skovlin-Garrison)

Analyses of forage samples collected throughout the 1958 grazing season show that during the fall months summer ranges in the Blue Mountains of Oregon do not supply the level of protein nutrition required for the proper maintenance of cattle. Considerable differences in protein content existed between species. Elk sedge contained the highest protein content after mid-season. Pinegrass began the grazing season with the highest protein content, but ended with the lowest. Except for Idaho fescue, late season phosphorus levels were also deficient. (Skovlin-Strickler)

Condition and trend of livestock range: Seventh-year remeasurements of vegetation on open grassland areas on the Starkey Experimental Range in eastern Oregon show that the general upward trend in range condition is continuing; however, rate of change has varied greatly between sites. The dominant species, bluebunch wheatgrass and Idaho fescue, made their best recovery on the well-drained, deeper Ukiah and Albee soils, but were just beginning to invade shallow Rock Creek soils. Thin bentgrass increased greatly in composition on Wilkens soil. On the other hand Sandberg bluegrass, a secondary species, had an average decrease of 22 per cent on all sites, and its larger losses were associated with the best recovery of the dominants on the deeper soils. Baltic rush decreased more than 30 per cent on Wilkens soil. The ruderals, western yarrow and gumweed, decreased 40 to 80 per cent on the range as a whole, but showed little change on the shallow and heavily used Rock Creek soils. These studies indicate the importance of site in the development of range conditions and trend standards. (Strickler-Garrison)

Use of fire on livestock range: June burning on the Santa Rita Experimental Range in Arizona significantly reduced the number of burrowweed plants, but had no consistent or significant effect on mesquite or cactus numbers. Some mesquite seedlings only 6 inches high sprouted after being burned to the ground. Most perennial grasses decreased in basal area following the fire but largely recovered the following year. (Cable)

Dominance of the site by pointleaf manzanita, a non-sprouting component of central Arizona chaparral, is apparently complete and continuous even following a fire which kills all living stems. Manzanita seedlings from seeds stored in the soil under the old plant crown rapidly become established in great abundance after burning to the exclusion of other plants. Within the periphery of the dense crown of mature plants, there is usually little else but a heavy cover of litter. (Pond)

Title: RANGE-USE RELATIONS PERTINENT TO MULTIPLE-USE MANAGEMENT ON FOREST AND RELATED RANGES

Objectives of this research are to determine: (1) the effects of timber production and cutting practices on forage for livestock or big game and reciprocal effects of forage production and grazing on timber (particularly reproduction), (2) the nature and degree of competition and compatibility between livestock and wildlife on various types of forest and related ranges, and (3) relations between grazing and watershed management on both forest and related ranges. Such research is needed as a basis for adjustments in livestock or game numbers and in management practices necessary for resolving conflicts in the various uses on both public and private lands.

Progress: Game-livestock relations: In a cooperative study with the Oregon State Game Commission, rumen samples from 17 male deer were collected during October, 1958. On the average bitterbrush provided 61 per cent of the diet of deer during the period of collection. Mountain mahogany, snowbrush, and Oregon grape each constituted about 10 per cent of the diet. Of interest is the large amount of snowbrush in the diet of individual deer. In one case this deer forage of questionable palatability provided 67 per cent of the rumen

volume. Apparently snowbrush is an important part of the diet under certain circumstances. Among other things, grouping of samples from deer collected in different vegetation types under variable weather conditions caused considerable variation in the results. Subsequent samples will be collected monthly from deer in specified vegetation types to provide for natural groupings. (Driscoll-Dealy)

Range-watershed relations: On the Rio Jemez watershed in northern New Mexico, soil pitting lost most of its effectiveness in reduction and retardation of surface runoff during a single summer-fall rainy season. Individual pits were completely filled with sediment. Tests were conducted on residual topsoil and exposed subsoil derived from shale. (Hickey)

Plant and ground cover in the salt desert shrub type of western Colorado changed very little during a 5-year period of protection from grazing. In 1953, four watersheds were fenced to exclude livestock, whereas winter grazing by both sheep and cattle was continued on four comparable areas. Bare soil and erosion pavement comprised about three-fourths of the ground surface in 1953. Remeasurements 5 years later showed practically no changes in vegetation or ground cover on either the grazed or ungrazed watersheds. (Turner)

Title: RANGE-PEST RELATIONS ON FOREST AND RELATED RANGES.

This research is concerned with effects of rodents, insects, and diseases on vegetation and soil of livestock range and wildlife habitat and with reciprocal effects of vegetation and soil condition and grazing practices on rodent or insect populations or disease incidence.

Progress: Rodent-range relations: Recently published results from a five-year study in Utah indicate that where pocket gophers are abundant some degree of control may be necessary to insure successful range seeding. Seeded grasses averaged 355 lbs. per acre on an area heavily infested with gophers, as pared to 1,195 lbs. per acre where gophers were controlled. Excellent stands of seedlings emerged the first year on both areas, but the grass cover declined progressively where gophers were not controlled. Seeded stands consisted of a mixture of timothy, orchardgrass, tall oatgrass, and smooth brome grass. (Julander)

Analysis of 213 pocket gopher stomachs collected periodically between June 29 and September 16, 1957, from mountain grassland range on Black Mesa, Colorado, shows that gopher diet consisted of 94 per cent forbs and 6 per cent grass, where vegetation composition was 50 per cent grass, 42 per cent forbs and 8 per cent shrubs. Preferred foods and the percentage each made up of total stomach contents were: Erigeron macranthus, 22 per cent; Lupinus spp., 14 per cent; Collomia linearis, 14 per cent; Taraxacum officinale, 12 per cent; Chrysopsis villosa, 11 per cent; Lathyrus leucanthus, 7 per cent; and Geranium fremontii, 7 per cent. As previously reported, reduction of these forbs by spraying with 2,4-D also causes a reduction in the gopher population. (Keith)

Pocket gophers on Black Mesa in western Colorado are active under the snow from March until snowmelt usually in June. During the past three winters, as the snowpack deepens in late winter, the soil thawed and gophers began to dig, both in the snow and in the soil. Excavated soil was packed into abandoned snow tunnels and after snowmelt was left on the ground as long slender casts. During three winters casts have covered an average of 7.3 per cent of the ground surface.

From November through February, gophers are relatively quiet within their burrows. At that time, snow is usually one to three feet deep and the surface soil is frozen, inhibiting digging activity. The main foods are forb roots that are probably obtained from food caches. During snowmelt gophers may move their nests and food caches into the snow to avoid wet soil or drowning. They remain above ground until their nests are exposed near the end of the snowmelt period when they return the dry nest material and food caches underground.

Gophers also breed under the snowpack and sometimes bear young in snow nests. On Black Mesa they breed once each year from late April through June. Young are born from late May through July. Litter size varies from 2 to 6 and averages 3.5 young per litter. (Keith)

COOPERATIVE REGIONAL RESEARCH PROJECTS

Title: PROJECT W-16 - ECONOMICS OF RANGE RESOURCE USE

Leader: Andrew Vanvig, Chairman, Regional Technical Committee

Cooperators: Arizona, California, Colorado, Hawaii, Idaho, Montana, Nevada, New Mexico, Oregon, Texas, Utah, and Wyoming Agricultural Experiment Stations; Forest Service, Farm Economics Research Division, A.R.S.; and the State Experiment Station Division, A.R.S., U.S.D.A.; Bureau of Land Management & Reclamation, Dept. of Interior.

PROGRESS OF WORK AND PRINCIPAL ACCOMPLISHMENTS:

Arizona's project was activated July 1, 1959. Arrangements have been made to gather physical input data on bulldozing and chaining velvet mesquite. The U. S. Forest Service has been contacted to obtain data on forage response from the Santa Rita Experiment Station. Methods for estimating costs of ranching operations and returns in Southern Arizona have been studied and procedures for obtaining this data have been established.

California - ARS - The Cooperative California ARS contributing project was reformulated during the year in keeping with the revision of the regional project statement. Emphasis has been shifted from study of individual practices to the place of range improvement in contributing to profitable livestock operations.

Work still to be completed under the original project includes four items: (1) costs and methods of fireline construction, (2) costs and methods of burning preparation and burning, (3) economics of fertilizing dryland ranges in California and (4) economics of the integration of dryland range and pasture for beef cattle production. The authors have set a deadline of 1960 for completion of all four reports.

Under the revised project statement two studies are now underway. The first is an investigation to determine the potential profit possibilities of improvement practices in cattle ranching in the Sierra-Nevada foothills of the San Joaquin Valley. The empirical data have been assembled and analysis is in progress. The second project involves a similar analysis of the role of range improvement practices in sheep ranching in the North Coastal section of California. Basic data are now being collected.

The California and Farm Economics Research Division members of the W-16 Committee have devoted much time to the preparation of two regional publications, namely: (1) "Economic Analysis of Range Improvement -- A guide to Decisions of Western Ranchers", and (2) "Methods, Costs and Returns in Improving Western Rangelands." Draft copies of both publications are being written for review by the W-16 Committee and publication is contemplated by June, 1960.

Colorado completed its work under W-16, July 1, 1959 and a manuscript summarizing their findings has been written.

Hawaii continued their work on the analysis of costs of various phases of range resource development particularly on fencing. A manuscript for a station bulletin entitled "The Economics of Ranch Fencing in Hawaii" will be finished by the end of this calendar year. The findings are based on a purposive sample of 30 ranchers, representing a large proportion of all ranch-land in the state. These ranchers constructed many different types of fences under different soil and topography conditions. Original cost, life and annual cost have been calculated for various modal types of fences. Many different factors affecting costs have been considered such as quality of materials used, quantity buying, cost of different types of labor, amount of machinery use, quality of fence construction, purpose of the fence, type of animals, financial condition of the ranches and management ability.

Idaho withdrew from the regional project July 1, 1959. A station bulletin reporting Costs and Benefits of Reseeding Southern Idaho Range Land is now in press.

Montana has continued its study on the effects of differences in grazing intensities upon weight gains of animals and condition of ranges. Walter Houston of the United States Range and Livestock Experiment Station re-investigated the original experiment on which Montana's Contributing Project to W-16 is based. His findings on certain other factors prompted a re-evaluation of the early results of Montana's Contributing Project. The budget results of previous work were statistically analyzed using both multiple regression and analysis of variance. Despite the fact that a positive and relatively consistent difference exists between the various levels of grazing, none of these differences are statistically significant. This throws serious doubt on the validity of conclusions previously reached. Complete evaluation and modifications of the work will have to wait until Houston's work is completed sometime next spring.

Nevada has begun work on an economic analysis of rehabilitating range seedings. Originally, the Bureau of Land Management had planned to spray a 5000 acre seeding. Sixty-six wire sampling cages were constructed and thirty-three paired samples were set up on line transects on a stratified randomized sample basis. However, Dr. Robertson and Glen Fulcher recommended against spraying since they felt it was not a good sample area. Instead a new seeded area on Forest Service land in the Sweetwater area has been selected for study and will be sprayed on a sample area basis next spring with Forest Service co-operation.

New Mexico has largely completed the field work for its crested wheatgrass study. About 15 ranch operators contacted in 1957 and 1958 were again contacted in November 1959 to obtain data on ranch organization, costs and returns. These data are to be used in measuring the economic effects of lambing ewes on crested wheatgrass in north-central New Mexico.

The project was revised in February of 1959 to provide for cooperative research with the Bureau of Indian Affairs on the Jicarilla Apache Reservation to determine the economic effects of grazing ewes and lambs summerlong on crested wheatgrass. The ewes averaged a 10 pound gain in weight per head over the period June 15 to September 15 or a gain of 22.8 pounds per acre. Utilization of crested wheatgrass was estimated in excess of 90 percent.

Oregon's work has been directed toward the determination of the economic returns over time which could be realized from range improvement practices by ranches of varying size and resource combination. Emphasis has been placed on chemical and mechanical control of sagebrush, reseeding, and related management practices. Experimental results in Oregon from chemical spraying indicate that a three-fold increase in herbage can be expected from this practice. However, a conservative estimate by the Oregon Range Management Specialist is that grazing rates could be doubled where herbage production is increased three-fold by chemical spraying of sagebrush.

Problems have also been encountered in attempting to translate herbage production from crested wheatgrass reseeding to grazing capacity. In many cases, the added grazing furnished by the reseeding takes early grazing pressure off the rest of the range which permits considerable increase in the productivity of the native range. Data has been collected from individual ranches with the view toward programming these individual situations in order to estimate rates of return from investments in the various classes of range improvement practices.

Utah's contributing project to W-16, Economics of Control of Undesirable Plants on Utah Ranges, was activated July 1, 1959. Work to date has been of an exploratory nature and has been useful in providing researchers with necessary background information. Also, problems are being isolated and put in operational terms. Work is beginning on the economics of poisonous plants.

Wyoming has continued its work on an economic evaluation of chemical sagebrush control. Work in 1959 has been focused on gathering material on (1) acreage and density of big sagebrush (*Artemesia tridentata*) in Wyoming, (2) experimental work with chemical control of sagebrush performed in the Western States, and (3) supplementary data needed to appraise the effects of sagebrush control such as stocking rates, and other aspects of ranch organization.

Data showing forage response after spraying is available from controlled experiments for three site conditions in Wyoming. Spraying resulted in increases of from 200 to 400% in grass production as compared to unsprayed areas depending upon elevation, precipitation, and other characteristics of the experimental area. Work is proceeding toward the determination of economic returns over time that can be expected from investments in chemical sagebrush control on representative ranches.

USEFULNESS OF FINDINGS:

Research work carried on under the W-16 regional project showing methods, costs, and returns of promising range improvement practices is of practical value to both ranchers and public land administrators in the Western region. Studies carried on under the second objective of the regional project are important to ranchers in determining the place of range improvement in profitable management of livestock ranches. On a broader scale, research findings on the economics of range resource use should provide a better basis for policy decisions regarding improvement and use of public lands.

WORK PLANNED FOR NEXT YEAR:

Arizona will continue gathering input data on the removal of mesquite by mechanical and chemical means. Case studies of budgets for selected ranchers will be made to determine costs of operating ranches in Southern Arizona. California - ARS plans to complete the two regional publications and continue their study of the place of range improvement in contributing to profitable livestock operations on California ranches.

Hawaii plans to continue field work and analysis of other improvement practices such as range clearing and seeding and their effect on management and ranch organization. Montana hopes to complete their study on the rates of stocking and plans to submit a new contributing project proposal early in 1960 for the consideration of the Committee.

Nevada will study the economic effects of spraying in the Sweetwater area and possibly other areas of the state to broaden the applicability of the research. New Mexico plans to summarize and publish data gathered in 1957-59 and also revise their contributing project objectives to include an inventory of range improvement practices in the state along with supporting data on costs and economic effects.

Oregon will continue its work in programming individual situations in order to estimate rates of return from investments in various range improvement practices. Utah expects to continue the general study of problems related to undesirable plants with early emphasis on the economics of poisonous plants on Utah ranges. Wyoming plans to survey ranchers and others to obtain additional data on ranch organization and forage response after spraying for a wider variety of site conditions.

Work will continue next year in the various states toward achieving the objectives of the revised regional project. At the annual meeting a sub-committee was appointed to study the possibilities for additional regional publications.

Title: PROJECT W-25 - ECOLOGY AND IMPROVEMENT OF BRUSH-INFESTED RANGELANDS

Leader: R. Merton Love, Chairman, Regional Technical Committee

Cooperators: Arizona, California (Davis and Berkeley), Colorado, Hawaii, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington and Wyoming Agricultural Experiment Stations; Intermountain Forest and Range Experiment Station; Weed Control in Grazing and Non-Crop Lands Section, Agricultural Research Service, the State Experiment Stations Division, Agricultural Research Service; Bureau of Land Management, and the Soil Conservation Service

PROGRESS OF WORK AND PRINCIPAL ACCOMPLISHMENTS:

The research conducted by the 12 participating western states falls naturally into three categories: seedling establishment, grazing practices and brush encroachment and range ecology and vegetation-soil relationships.

Group 1: Seedling establishment.

California: Brush establishment in relation to soil fertility levels. Emphasis in 1959 was placed on the effects of a stand of brush, compared to one of grass, on soil properties. The ultimate objective is to determine the fertility levels of brush and grass species in relation to soil types in order to aid in recommendations resulting in higher land use of brush-infested land

There is a differential uptake of N and P, independent of the amount of these elements in the soil, by both grass and brush plants when grown on soil currently supporting brush or grass cover. The relative uptakes are changed when brush and grass species are grown in competition with each other, as compared with pure stands. Tests were run on seven soils. In six of the seven comparisons more N was available for larger grass yields on soils supporting brush, and five of the seven for larger brush yields on soils supporting brush. In four of the seven comparisons more P was available for larger grass yields on soils supporting brush, and in six of the seven for larger brush yields on soils supporting brush.

Montana: Sagebrush germination as affected by physical factors related to artificial control measures used on sagebrush infested rangelands. Laboratory tests showed that germination percentage was slightly lower at 75° F. than at 40° F., 32-40° F. 12-hour alternating temperatures, and 32° F. Maximum germination was 65%. Moisture level trials at 60° F. resulted in higher germination percentage with intermittent watering regimes. There is a wide variability of germination within accessions.

Wyoming: Field germination and grass seedling establishment on range land. The study of the ecotypes of big sagebrush and its relatives has been completed for the eleven western states and adjacent portions of Mexico and Canada. As one result of this work two new subspecies (Artemisia tripartita subsp. rupicola and A. arbuscula subsp. thermopola) and one new species (A. argilosa) have been described within the section Tridentatae. In addition, several new combinations have been proposed.

A sagebrush garden has been partially established in order to study the significant habitat factors affected by dominance of sagebrush. Variability among populations will be analyzed. Relation of sagebrush to animals, especially insects, will be studied.

Group 2: Grazing practices and brush encroachment.

Arizona: Changes in the desert grassland - an analysis of causes. (1) Ecology of creosotebush (Larrea tridentata) in the desert grassland; and (2) Tobosagrass (Hilaria mutica) a desert grassland association. Creosotebush survives burning. Germination has been obtained under widely varying conditions of temperature (10° C. to 45° C.), light (absence or presence, red and far-red), and pH. Seedlings are very susceptible to damping off in the greenhouse. Cleared areas are being observed to note rate of re-establishment and growth under natural conditions.

Tobosagrass is under study at three sites. Soil moisture analyses were made initially at all three and weekly at one at depths of 0", 6", 12", and 18" under the grass and also under adjacent shrub areas for comparison. During the summer rainy period soil moisture was highest at 6" under both covers, but the grass-covered soil averaged 1.5 to 2.0 times higher moisture in the top 18" than did the shrub covered soil. One month after the end of the rainy season the highest moisture percentage occurred at 12" under both regimes.

Colorado: Forage production and species composition of sagebrush ranges as affected by climate, soil moisture, and intensity of grazing. Five years of work indicate that sudden and drastic ecological effects cannot be expected from different grazing pressures on sand-sage grassland areas. Heavy grazing pressure has consistently resulted in greatest beef production per acre (averaging 63 lb. compared with 26 lb. with light grazing pressure). Calamovilfa longifolia (sand reedgrass) is most susceptible of the herbaceous species in succumbing to the effects of heavy grazing pressure. There has been insufficient reproduction of sand sagebrush to warrant conclusions. Annual forage production fluctuates in direct-relation to annual precipitation variation. It has been impossible to date to calibrate the Colman soil moisture units by the gravimetric method.

Hawaii: Methods in, and evaluation of, range improvement practices in the humid lowland areas of Hawaii. The combination of Kaimi clover and Digitaria decumbens (pangola-grass) has been shown to be ideal for beef production in replacing Psidium guajava (guava, the foremost noxious shrub of humid lowlands).

Application of lime (2,000 lb. to 8,000 lb. per acre) resulted in a 46% increase in liveweight gains, with a 20% increase in dry matter yield of forage. No marked responses were obtained to levels of liming. Lime plus complete fertilizer depressed liveweight gains (37% increase compared with 46%) even though this combination increased dry matter production (39% increase over check compared with 20% for lime alone).

Per acre beef production reached 588 lb. for the year and each animal made 515 lb. of liveweight gain and was ready for market in 12 months of age. Carcasses were just short of choice and were followed through to the retail outlet.

Nevada: Management of crested wheatgrass range pastures to delay encroachment by undesirable brush. After five years heavy, late grazing has kept the most favorable balance between grass and brush where the initial grass stand was sparse. Moderate spring season-long grazing maintained the best balance where the initial grass stand was thick. Seven patterns of grazing are being used in this experiment in cooperation with local ranchers, U. S. Forest Service, and U. S. Bureau of Land Management. Livestock gains per acre at different stocking rates confirmed last year's data.

It is clear, after four years of differential grazing, that the stability of a vigorous young stand of crested wheatgrass is not easily upset. It is important to know how many years of heavy grazing this can withstand.

New Mexico: Ecology of creosotebush (*Larrea divaricata*) on desert grassland. Definite improvement of bunchgrass range has been noted at each plot location under the combination of brush removal and exclusion of livestock. Results to date indicate that creosotebush is not a rapid invader of the range, but once established grows to mature size in 10 to 12 years. Seedling establishment takes place at a high rate only in the rarely-occurring favorable years. Livestock and rabbits are instrumental in causing marked reduction of fruiting.

Group 3: Range ecology and vegetation-soil relationships.

Idaho: Development of a fundamental vegetation-soils classification of non-forested ranges in Idaho as a basis for range improvement and management. Yield studies were continued on two sites started in 1958. A number of areas were located in east-central Idaho for future study. Detailed plans were made for studies of the effect of cover manipulation of shrubs on the production and composition of associated vegetation. There is now available a full set of profile descriptions and physical analyses of the soils on all 65 study sites. Chemical analyses are complete for 27 sites. Analysis of vegetational data for all sites was started using the ordination approach developed by the University of Wisconsin.

Oregon: Development of fundamental vegetation-soils classification for non-forested ranges in Oregon as a basis for range improvement and management. Vegetation data are complete on 43 new study areas in the Columbia Basin. Except for moisture equivalent and texture analysis, soil data are complete. A follow-up comparison of the Parker loop and ocular estimate methods has been designed and laid out to provide improved estimates of sampling intensity. A start has been made in analyzing successions in some of the habitat types. In order to identify the soil factors that appear to limit species composition and/or dominance quantitative relationships of specific vegetation and soils characteristics are being determined. A comprehensive analysis of climatic patterns is being prepared as a background for interpretation of other data.

Utah: Plant and soil relationships determining changes in plant cover on desert shrub range land. Four Atriplex communities have been studied in eastern Utah. A. confertifolia - Hilaria jamesii, A. nuttallii subsp. nuttallii - H. jamesii, A. nuttallii subsp. gardneri - Aster venosus, and A. corrugata appear to be associated with particular soils which are now being analyzed. Sphaeralcea grassulariaefolia germinates best at 22° C. (dropping off at lower and higher temperatures); scarification (chemical or mechanical) enhances germination.

Spring clipping of the seven important desert species over a 3-year period caused greater reduction of vigor and mortality than did early or late winter clipping. These studies involving three years at four intensities and at four seasons showed that 75% utilization was more harmful than 50% or 25%.

Washington: Development of a fundamental vegetation-soils classification for arid portions of Washington as a basis for range improvement. On seven sites west of Spokane vegetational analysis is complete; the soils samples will be studied this winter.

Grayia spinosa is very palatable. Under it the heavy litter keeps the soil well aggregated despite the excessive K and Mg accumulated by the plants. When the brush is removed the soil puddles markedly. No young plants have been found.

On a high ridge in the Rattlesnake Mountains a steep gradient 300 m. in length passes from a cool-wet to warm-dry environment. The hypothesis - that climate rather than soil, grazing history, or some other factor is the most tenable explanation of the gradient on the basal plain - will be tested on this steep gradient.

Second year studies of recovery of Agropyron spicatum following fires of moderate intensity on two sites showed: for the one 18% cover compared with 11% the first year and 49% before the fire, and for the second site 21%, 11% and 62%, respectively.

Studies are underway to attempt to discover whether pH, salinity, or water-holding capacity will distinguish Distichlis - Elymus cinereus from Distichlis - Sarcobatus types on six areas of halomorphic soils.

Group 4: Federal Agencies.

No formal reports were submitted this year, since cooperative work has been included in the state reports. Dayton Klingman, Agricultural Research Service, reported briefly on his section's range weed research.

USEFULNESS OF FINDINGS:

Brush and unwanted trees cover vast areas in the Western region. Where studies have been made, especially in the Southwest, it has been shown that lands once fairly open have become more densely covered with brush in the past 20 years.

Collaborators in California, Montana and Wyoming are studying the factors involved in brush versus grass seedling establishment. The vegetative cover has a marked influence on soil P and N. The major sagebrush types have been delineated and a sagebrush garden has been established in order that further ecological studies can be made. The temperature and moisture requirements for sagebrush germination have been fairly well worked out.

Collaborators in Arizona, Colorado, Hawaii, Nevada and New Mexico are studying the effects of grazing practices on brush encroachment. The differential responses of desired forage plants and unwanted creosotebush, sand sage, guava and sagebrush are being determined. Significant progress has been made, but five years is insufficient time to develop definite conclusions. In Colorado, sand reedgrass has been shown to be the key forage species to watch because of its susceptibility to heavy grazing pressure.

Collaborators in Idaho, Oregon, Utah and Washington are determining the ecological factors involved in vegetation-soil relationships. To date, over 30 basic vegetation types have been delineated in the sagebrush area of the West.

Throughout the 12 western states the fundamental bases are being laid upon which sound research programs are being developed. These in turn are designed to prepare a framework for good grazing management of improved ranges.

WORK PLANNED FOR NEXT YEAR:

The W-25 regional research project is now up for revision, but a brief statement here is in order.

Group 1:

California: Germination aspects of brush-grass seedling establishment have been by-passed and will be studied next. The nature and role of inhibitors, if any, (their effect on germination, growth and response to fertilizers) will be investigated.

Montana: Field studies which have been initiated on germination of sagebrush seed will be intensified. For example, locally collected seed is being planted at 2-week intervals on soil from which sagebrush has been removed.

Wyoming: The sagebrush garden establishment will be continued. Variability among populations will be analyzed. Work on the relation of sagebrush to animals, especially insects, will be initiated.

Group 2:

Arizona: Studies on the environmental factors affecting the composition of creosotebush and tobosagrass communities will be intensified. As a result management techniques will be indicated.

Colorado: The effects of differential grazing effects on sand-sage grass range are just becoming evident. The study is to continue to note the effects on forage production, species composition and soil moisture.

Hawaii: A second series of grazing trials will be completed on guava-infested range converted to grass-legume.

Nevada: As in Colorado, grazing studies will continue in order to find the "breaking-point" of crested wheatgrass on sagebrush-cleared range. The 1954 transects will be re-photographed.

New Mexico: Work will be expanded on the value of a competitive cover of grass in preventing establishment of creosotebush. This will include grass competition with older brush plants. Pot tests will be run on soils from areas where creosotebush has been removed. Life history studies will continue.

Group 3:

Idaho: Sagebrush thinning and other cover-manipulation studies will be initiated. Vegetation and soils will be analyzed within and adjacent to enclosures. I.B.M. processing of data will be investigated.

Oregon: Soil sample analyses, quantitative relationships between vegetation types and soils, and analysis of data will continue. It is expected that the methods study (random vs. permanent plot locations) will be completed.

Utah: Studies of plant response to grazing will be redesigned in order to intensify the procedures. Previously analyzed communities will be sampled again to note whether changes have occurred. Autecological studies will continue. Work will be started on three communities at three locations on environmental measurements to be correlated with phenology.

Washington: Many facets warrant continued study. Annual variations in productivity of two cover types (cheatgrass and Agropyron) typical of areas where heavy infestations of rabbitbrush often occur. Additional series of vegetation types will be studied.

Title: PROJECT W-34 - RANGE LIVESTOCK NUTRITION

Leader: I. A. Dyer, Chairman, Regional Technical Committee

Cooperators: Arizona, California, Colorado, Hawaii, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington and Wyoming Agricultural Experiment Stations

PROGRESS OF WORK AND PRINCIPAL ACCOMPLISHMENTS:

A. Chemical composition of range plants.

Eight of the Stations have sampled systematically various species of range forage. A determination of the proximate fractions were determined on most forage samples. Work plans from some of these Stations required a more detailed analysis than is afforded by the proximate scheme. Hence, such determinations as calcium, phosphorus, carotene, chromogen, lignin and other constituents were made as needed at the various stations. The individual data, or even specie analysis at different locations and seasons are too voluminous to include in this summary. Those wishing to obtain data should consult the individual project progress reports for 1956-1959, and/or publications emanating from this work.

The California Station has developed an esophageal fistula for sheep. Forage samples collected through this fistula have been used to study botanical composition. This procedure affords a representative forage sample for analysis. Browse (live oak and chamise) samples were also collected, analyzed and digestibility determined. Another contribution from this station was showing that the lignin ratio and the chromogen methods of determining digestibility have limitations.

The Colorado Station has analyzed forage at different stages of maturity so that a judicious supplementing program could be effected. This work indicated that a dehydrated alfalfa supplement is superior to conventional protein supplements for range cattle. Also, variable protein supplementation to balance seasonal differences in range forages is superior to providing a protein supplement only during the winter months. Data from Colorado indicate that rotational grazing is not as satisfactory as continuous grazing of native range.

Intensity of grazing and chemical composition of native and seeded forages and the effect of these variables on production have been studied at the Idaho Station. Their data indicate that range forage is adequate in protein but deficient in energy during the early grazing period. On the other hand, crested wheatgrass provides an adequate amount of protein and energy but is borderline in phosphorus and deficient in calcium during the same period. Fall grazing of crested wheatgrass showed it to have an inadequate amount of protein, calcium and phosphorus.

The Montana Station has analyzed the major species of range forage in their test plots and simultaneously have determined plasma carotenoids, vitamin A and phosphorus. The major forage species analyzed include Agropyron smithii, Agropyron spicatum, Bouteloua gracilis, Bromus tectorom, Buchloe dactyloides, Muhlenbergia sp., Stipa comata, Carex filifolia, Eurotia lanata, Artemisia cana, Atriplex confertifolia, Atriplex sp., and Sarcobatus sp. Data from Montana's work emphasizes the error in taking one or only a few blood samples and attempting to generalize on the nutrient adequacy of the range throughout the year.

Observations that cattle from Southern Nevada are retarded in growth and have different levels of blood constituents than cattle from the Northern part of the state were reported. Cattle from northern Nevada had higher hematocrit values than comparable cattle from southern Nevada. Earlier work on this project established the forage composition in the two locations. Later work has dealt with a supplemental feeding program to correct the existing deficiency or deficiencies observed on the Southern range.

The New Mexico Station has worked extensively with the chemical composition of range forage as influenced by season and location. Their data indicate a significant linear relationship between plasma vitamin A and the logarithm of forage carotene intake. Temperature was found to influence the forage carotene content more than rainfall. Forage crops in New Mexico, as well as in most other range areas, are deficient in phosphorus.

The chemical composition of crested wheatgrass has been elucidated at the Oregon Station. The chemical analysis per se was incidental since their major objective was that of developing techniques for measuring range forage consumption and quality.

The Utah Station has worked extensively with salt-desert forage species. Their analyses indicate that the chemical content of these forages vary significantly among species. In early fall, grasses were higher in cellulose; shrubs were higher in ether extract, protein, lignin, calcium and phosphorus. As the season advanced (October to March), lignin and cellulose showed a general increase whereas ether extract, protein and the more soluble carbohydrates decreased. The ash content of the grasses was higher in the lower portion of the plants while in the shrubs, ash was higher in the upper portions. The Utah workers suggest that certain plants may translocate protein from stem tip to the base during the winter.

Forage samples were collected from two ranches at monthly intervals at the Washington Station, during the past year. The predominate species (Agropyron spicatum, Bromus tectorum and Festuca idahonesis) were collected from 10 different locations. A detailed analyses of the plants, soil, and water is being made to see if the "crooked calf" malady is related to the composition of either the soil, water or forage.

Considerable time and effort by members of the W-34 Technical Committee have been devoted to the analyses of range forage and shrubs during the first four years. We obviously do not now know the composition of range forage under all conditions. Yet, with the knowledge obtained, it appears that we should

analyze the forage as a means to an end rather than an end within itself.

B. Range Research Techniques:

The esophageal fistula technique for sampling forage and browse has been used extensively at the California Station. Their work with this technique indicates:

1. The care of the fistulated sheep following the operation has been simplified by reinforcing the area with tantalum gauze six weeks before the fistula is actually installed in the esophagus.
2. A technique for determining the dry matter of grazed forage has been developed using tritium (H^3) as a tracer.
3. Statistical studies on within-sheep variation and between-sheep variation indicate that only one collection per sheep per day should be made as second collections vary in an unpredictable manner from first collections. Between-sheep variations is such that Latin squares or incomplete Latin squares are recommended so that all sheep collect in more than one treatment.

The Nevada Station reported experimental evidence which indicated that esophageal fistula did not give total collection of grazed samples. Selective grazing was demonstrated by both the chemical and botanical composition of the ingested forage.

Pasture production and utilization was determined at the Idaho Station by clipping specified forage areas before and after grazing. This information with their indicator data lends itself to an estimation of the dry matter intake and digestibility of the forage.

Oregon State and Wyoming have evaluated techniques for measuring range feed consumption and utilization. Since plant maturation affects quality and quantity of range forage, experiments were conducted using forages at different stages of maturity. Various methods of measuring digestibilities of range forage were evaluated. Among them were the chromogen, chromic oxide, and nitrogen methods. Formulas were developed by the Oregon Station for predicting dry matter intake and fecal excretion. Another interesting observation from Oregon was that fistulated (rumen) steers graze normally, when with other steers, and that the rumen may be emptied for analytical determinations.

An improved rangemeter was developed at the Utah Station to determine distance traveled by range animals. This has many practical applications as well as some of a more fundamental nature such as the computation of energy expenditure for activity. Methods of individually feeding cattle on the range were also described.

C. Animal Performance:

All stations have evaluated the effect of various imposed conditions on animal performance. This has been the major objectives of some stations while incidental in others.

California has studied the nutrient intake of sheep in relation to their requirement for TDN and DCP. Their data indicate that the unnatural handling condition resulted in a negative energy and nitrogen balance. Lowered consumption by cattle and sheep wearing a collection apparatus was also observed.

Considerable work has been done at the Colorado Station on the range forage consumption by cattle. Also, their data show a considerable amount of forage disappearance due to jack rabbits (373 and 580 pounds per acre for the lightly and heavily grazed plots, respectively.) These workers have also studied the effect of protein supplementation of native pasture on performance of cows and their calves.

Gains of cattle during four years of study at Idaho reflect differences in quality of forage because of seasonal variation. Further, the in-season variation, due to the favorable or unfavorable growing season, affected rates of gain. As would be expected, gains were greatest in the spring whereas in the fall, the dry forage provided primarily a maintenance ration. Adequacy of the forage for cattle during the various seasons with respect to energy, protein, calcium and phosphorus was evaluated.

Montana worked extensively with range supplementation. They found that the addition of phosphorus and vitamin A to the supplemental pellet tended to increase gains during the winter. During one winter, supplemented steers gained 90 pounds more than those without a supplement. Also, yearling steers self-fed a 70 - 30 cottonseed meal-salt mixture on summer range from August to October gained from 13 to 51 pounds more than unsupplemented steers. Blood constituents were normal during both the winter and summer.

The Nevada Station showed the effect on weight gains of gestating cows and on calving per cent and number of calves lost by supplementing with barley, soybean oil meal and alfalfa. Their data also showed the effect of supplementation on various blood values. The hematocrit was significantly influenced by protein supplementation. They reported that plasma fat is increased by feeding starchy carbohydrates or fats.

Cattle under range conditions in New Mexico exhibited no vitamin A deficiency symptoms. Plasma carotene and A were below normal for only short periods of time when the forage was devoid of carotene. Calving percentages were also considered normal. New Mexico's data show the necessity of phosphorus supplementation for range cattle.

Pure protein (Drackett) was of no benefit in increasing digestibility of dry matter according to Oregon work. This protein was added so that the rations contained 7, 9, 11 and 13 per cent crude protein. Digestibility determined by the nitrogen--dry matter ratio was similar to digestibilities determined by the total collection method.

Experiments at the Utah Station show the effect of restricted water intake on feed consumption and performance of beef cattle. When water was given at 100, 75 and 50 per cent increments, voluntary feed consumption was similarly reduced as was also the gains. When water was given each day, every second and every third day, feed intake and gains were lowered proportionally. In each instance the lower water intake resulted in a true live weight loss.

Utah has also worked extensively with range supplementation. Their data indicate that high levels of protein (2 lbs. per day) gave no weight response and probably contributed to calving difficulty in heifers. On the other hand, protein supplementation of cows, over a three year period, was beneficial. Sugar (1.6 lb. per head daily) additions resulted in scouring. Calf birth weights were not increased by sugar additions. No phosphorus deficiencies were observed.

A detailed study of the effects of protein, mineral, and vitamin A supplementation to low quality roughage rations has been completed at the Washington Station. Their results indicate that:

1. The increase in performance as a result of feeding a high quality hay such as alfalfa is due to a number of nutrients, principally protein, energy, carotene and minerals.
2. Either wheat straw or crested wheat grass straw can supply a satisfactory source of energy, if supplemented with the nutrients in which it is lacking.
3. Utilization of wheat straw is enhanced by increasing the available nitrogen in the form of urea, or supplying minerals in the form of alfalfa ash.
4. Gestating heifers consuming primarily wheat straw cannot maintain their liver vitamin A stores. Further, insipient vitamin A deficiency symptoms will depend on initial vitamin A stores in the animal.
5. Dehydrated alfalfa did not stimulate consumption of wheat straw. The addition of dehydrated alfalfa to rations containing high levels of wheat straw significantly ($P < 0.1$) reduced crude fiber digestion.

Wyoming reports that the digestibility of high quality hay from S. E. Wyoming has a TDN value approximately 10 per cent higher than is listed in Morrison's Text. Their digestibility studies indicate no specific diurnal trend in chromic oxide and chromogen excretion.

USEFULNESS OF FINDINGS:

- A. Range forage analyses are useful in determining the time of year at which supplementation is desirable and in determining the kind and amount of supplement which might prove most beneficial. It is also beneficial to know the effect of various management practices such as fertilization and grazing intensities since these practices often influence the yield and composition of the forage.
- B. The kind and amount of forage consumed by grazing animals is of inestimable value in determining animal preferences and the nutrient deficiencies and abundances of his diet.
- C. Tissue analyses when combined with other data such as forage analyses are making it possible to locate more accurately regions and seasons of critical shortages and abundances of nutrients. In finally testing grazing practices, the productive performance of animals must be obtained. The production data, therefore, is of utmost value in the final testing before practices are recommended to the livestock producer.

WORK PLANNED FOR NEXT YEAR:

Each station is continuing with the objectives enumerated in their latest approved project outlines. Revisions of the W-34 Master Project and of the contributing projects are due this year (1959). The revised projects will, therefore, be approved and rated in 1959 and are to become effective July 1, 1960.

Title: PROJECT W-46 - THE EFFECTS OF ENVIRONMENTAL STRESSES ON RANGE CATTLE AND SHEEP PRODUCTION

Leader: C. P. Stroble, Chairman, Regional Technical Committee

Cooperators: Arizona, California, Colorado, Hawaii, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, and Wyoming Agricultural Experiment Stations; Agricultural Research Service; and the State Experiment Stations Division, ARS, USDA

PROGRESS OF WORK AND PRINCIPAL ACCOMPLISHMENTS:

The effect of diet on early post-partum stomach development has been investigated (Idaho). A roughage ration was found to be no more effective in development of rumen, reticulum, and omasum than was a concentrate ration. Milk alone fails to encourage the development of these stomach compartments. The development of the rumen was greater in calves fed a completely pelleted ration than in those fed a ground ration. This same relationship was true in respect to increase in weight of the entire system.

The effect of diurnal variation in water consumption, urine volume, total urine nitrogen, total creatinine, total ammonia and total urea shows the difficulty of using a single daily value for comparative purposes (Arizona). Extreme changes in altitude of approximately 8000 feet appeared to elicit stress response in hemoglobin molecule constitution, shown by a decline in iron content per unit color density (Colorado). The consumption of saline water (2.0% NaCl) resulted in severe hemoconcentration as indicated by hematocrit and blood specific gravity observations. The consumption of 2.0% salt water also caused a significant increase in serum sodium. Blood urea was decreased by both 1.0% and 2.0% salt water treatments. It appears that growing cattle can tolerate 1.0% salt water, at least during cold weather, but 2.0% salt water is toxic (Nevada). The addition of sodium propionate did not improve the performance of sheep or restricted energy and protein intake as measured by weight gains, nitrogen balance, body composition or blood glucose and ketones (California).

Normal values for hemoglobin, hematocrit, red cell count, mean corpuscular volume, mean corpuscular hemoglobin concentration, white cell count, lymphocyte, neutrophil, monocyte, eosinophil, and basophil counts were investigated (Oregon).

Blood cell volume (hematocrit) and hemoglobin values were found closely related in cattle. No positive relationship was found between these values and rate of gain (New Mexico).

Carcass composition was not effected by feed restriction; however, the composition of weight loss showed some variation because of loss of fill (California).

The normal electrocardiogram, and mechanisms controlling cardiac adjustment were studied (Oregon). The electrocardiogram may prove a most valuable tool for the assessment of stress.

Flushing results in greater post-partum body weight in two- and three-year-old ewes. In the mature ewe, flushing results in the product of more ova. The number of abnormal ova recovered was small in all cases; however, flushing did increase the number of abnormal ova from the two-year-old ewes (Montana).

Protein supplementation had no statistically important effect on pasture fed weanling Hereford heifers; however, the supplemented heifers did gain more than did the unsupplemented heifers (New Mexico). The critical level of protein in the ration of ewes was found to be below 7.0%. Ewes bred to lambs as two-year-olds may be seriously handicapped in reaching potential body size if subjected to relatively severe protein restriction during gestation (Utah). The lambs from stress fed ewes (66% of N.R.C. recommendations on dry matter basis), were born lighter, but weaned heavier than those from full fed ewes. This may indicate a compensatory adjustment in maintenance requirement by the stress fed ewes (Wyoming).

Differences in growth and wool production by genetically stabilized rams runs to be relatively unaffected by location when nutrition is constant. Where differences can be attributed to feeding and management practices they are quite large (ARS).

USEFULNESS OF FINDINGS:

The establishment of normal values for many of the more commonly investigated blood constituents will be a most useful basis of comparison when studying these constituents as indicators of the effects of environmental stress. Cardiac response to applied stresses can now be assessed with confidence. The addition of sodium propionate did not alleviate the effects of energy or protein restriction. Growing cattle can, at least during cold weather, tolerate 1.0% salt water. Carcass composition, as measured by specific gravity, was not affected by feed restriction.

Studies indicate that the rumen, reticulum, and omasum of young calves develop equally as well on a concentrate ration as on a roughage ration. The advantage of protein supplementation on pasture fed heifers, while present, was not statistically significant. Relatively severe protein restriction on gestating two-year-old ewes was found to be a handicap to their reaching potential body size.

Stress fed pregnant ewes apparently undergo a compensatory adjustment in maintenance requirements. Feeding and management practices are far more effective in growth and wool production than is geographical location or climate.

WORK PLANNED FOR NEXT YEAR:

A. The master project is being amended to up-date the section on Previous Work and Present Status, and to more clearly define the section on Procedure. Most contributing projects are being revised or amended.

B. Plan of Contributors:

1. Arizona: The acquisition of a climate chamber makes possible highly critical studies of thermal stress. This station will study: 1. The establishment of objective measure of animal response to thermal stress; 2. The alteration of blood constituents at high temperature as affected by hormonal and nutritional factors; 3. The physiological changes associated with adaptation to high temperatures; and 4. The development of methods for alleviating thermal stress.
2. California: Study the influence of various degrees of energy restriction on body composition, subsequent recovery and energy utilization. Determine if the relationship between energy intake and energy retention is rectilinear or curvilinear, or both, depending on the plane of nutrition.
3. Colorado: Investigate the metabolism of vanadium by the mammal including studies pertinent to effect on rumen digestion, intermediary metabolism, toxic forms and levels, symptoms of toxicity, and general effects on growth, reproduction, lactation, blood picture, and body composition. Investigate effectiveness and suitability of possible antagonist for the control of vanadium toxicity in animal organisms.
4. Hawaii: (tentative) Study the physiological response of Targhee sheep to an environment which provides: 1. sea level altitude, 2. narrow temperature range (65° - 90° F.), 3. small differential in daylight bright during the year, and 4. a high sunlight intensity. Compare results under this environment with as diverse environment as possible both within Hawaii and the mainland Western States to measure the stress involved in differential climatic environments.
5. Idaho: Study the effect of ration, salt, and salt water on stomach development in the young calf as measured by weight and volume of divisions and by weight and growth of the papillae of each stomach division.
6. Montana: Continue study of effect of protein supplementation on various aspects of reproduction in range ewes; special reference to lack of fertilization of normal ova.
7. Nevada: Study the effects of synthetically mineralized water on range livestock. Study the effects of naturally occurring mineralized waters on range livestock.

8. New Mexico: Study the effects of nutrient restriction following weaning on the growth of heifers and upon subsequent lifetime proudction. Study the relationship between certain blood constituents and growth and reproduction of heifers developed under nutrient restriction.
9. Oregon: Study the nature of cardiac adjustments, under normal and stress conditions including altitude, and to study cardiac activity as an index of stress. Study the mechanisms of alterations in cardiac activity in beef cattle and sheep.
10. Utah: Evaluation of more effective methods of estimating the physiological well-being of range sheep and cattle. Determination of the effect of nutritive levels upon the growth and reproduction of sheep and cattle when maintained under natural stresses of climate.
11. Wyoming: Study the physiological response of bred ewes to swine and moderate nutrient restriction as measured in terms of production. Study the usefulness of Chemical (Blood constituents) and physical (body weight, body composition and electrocardiographic changes) as means of diagnosing and evaluating nutritional stress.
12. U.S.D.A.: Repetition of first two years work using larger numbers. Fewer studies on single fibers are anticipated.

Title: PROJECT GP-6 - SEEDLING ESTABLISHMENT OF RANGE PLANTS IN THE GREAT PLAINS

Leader: Clint H. Wasser, Chairman, Regional Technical Committee

Cooperators: Crops Research Division, Soil and Water Conservation Division, Agricultural Research Service; The Agricultural Experiment Stations of the Great Plains Region; and the U. S. Forest Service

Objectives: 1. To develop laboratory methods for accurately estimating seed quality.

2. To investigate physiological requirements for maximum germination of seeds and optimum growth of seedlings.

3. To investigate seed treatments and placement as they influence stand establishment.

4. To investigate edaphic and microclimatic factors as they influence seedling establishment.

5. To develop improved field practices and equipment for reducing risk in obtaining stands of range plants.

6. To study the biology of stand establishment.

Progress: This is a new regional project, and research in support of it is just being organized in the participating states.

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